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Contents

THE OHIO STATE UNIVERSITY

OARDC

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Director

On the Cover: Ken Cochran, Secrest Arboretum curator, examines junipers for tip die back/damage. This Deciduous Shrub and Juniper Evaluation Plot was planted in 1986 specifically to evaluate the organisms that cause tip die back. See page 41 for a report on the findings of this interdisciplinary team.

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The Effect of Slow-Release Herbicide Tablets on Container-Grown Woody and Herbaceous Landscape Crops

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Abstract

A study was conducted to evaluate the effectiveness of slow-release herbicide tablets on herbaceous and woody container-grown nursery stock. The tablets contained oxyfluorfen (Goal) at 0.5 lbs active ingredient per acre (aia) metolachlor (Pennant) at 2.0 lbs aia and the surfactant Triton X-100 at 2 percent by volume.

At 10 weeks, weed control was acceptable at 1 tablet/1 gal. container, 2 tablets/2 gal. container, 3 tablets/3 gal. container, and 4 tablets/5 gal. container. One additional tablet/container increased weed control, but only slightly. Only Gold Flame spirea was injured among the seven herbaceous plants and 16 woody selections in the study.

The larger tablet size, lower pressure and increased soluble herbicide (Pennant) and surfactant concentrations combined to improve weed control over previous tablet evaluations.

Introduction

The application of herbicides to container-grown nursery crops through the use of slow-release tablets have several advantages. These include greater safety for humans, reduced herbicides in the environment as well as precise application to the target site (6). Several studies have been conducted to develop slow-release herbicide tablets that provide long lasting, wide spectrum weed control without plant phytotoxicity (2,3,4,5,6,7,8).

Research by Horowitz et al (1) has shown that surfactants added to the tablet increase the area of weed control. Follow-up studies have involved additional screening of surfactants and herbicides to achieve broad spectrum weed control over a greater area than was formerly possible without surfactants. The combination of metolachlor at 0.5 lb aia and oxyflurofen at 0.5 lb aia with the surfactant Triton X-100 was the most effective treatment in greenhouse studies (6).

As a follow-up to these studies, the objectives were to increase weed control by 1) increasing the amount of soluble herbicide, 2) decreasing the degree of tablet hardness, 3) increasing tablet size and 4) increasing the surfactant in each tablet. In addition to increasing per cent weed control from each tablet a second objective was to decrease the number of tablets required per container. The final objective was to evaluate the tablets for phytotoxicity on woody and herbaceous landscape crops produced in containers.

Materials and Methods

The tablets were made with a Stokes single-punch tablet machine utilizing commercial formulations of herbicides and a surfactant, dicalcium phosphate (as a filler) and magnesium stearate (as a binder). Finished tablets weighed 1.75 g/tablet. This compared with a 1.25 g/tablet utilized in studies in previous seasons.

The tablet composition consisted of oxyfluorfen at 0.5 lbs active ingredient per acre (aia) and metolachlor at 2.0 lbs aia. Triton X-100 was combined at 2 percent of the total volume. The pressure during the dry compression was 6.5 psi which is less than the 8.0-8.5 psi of previous studies.

The plants representing both woody and herbaceous selections were grown in 1, 2 or 3 gal containers and treated as follows:

1 gal container=1 and 2 tablets/container
2 gal container=2 and 3 tablets/container
3 gal container=3 and 4 tablets/container

These numbers represent one or two fewer tablets/container than were utilized in 1989 research.

There were three treatments, three plants/treatment, and three replications for a total of 27 plants/species and 23 species for a grand total of 621 plants in the study.

Plants were located in The Ohio State University container nursery randomized in a complete block design and maintained as for commercial nursery practices.

Results and Discussion

The rates of application in previous studies were higher than desired (6) and a major objective of this research was to examine the possibility of reducing the number of slow release tablets required for acceptable weed control. After 10 weeks, weed control averaged for all 23 species and cultivars as follows:

1 Gallon	1 tablet	8.4
	2 tablets	9.1
2 Gallons	2 tablets	9.1
	3 tablets	9.4
3 Gallons	3 tablets	7.7
	4 tablets	7.8
5 Gallons	4 tablets	10.0
	5 tablets	10.0
Control	(no tablets)	7.5

In general, weed control was most satisfactory and suggests that acceptable control lasts for more than 10 weeks. Further, it suggests acceptable weed control with the lower rates in all container sizes. The additional one tablet per container does enhance weed control but the increase from 8.8 to 9.1 representing the lowest to the highest tablet number was not significant.

Weeds controlled in the study included crabgrass, chickweed, groundsel, prickly sida, wild lettuce, and Canadian thistle. Early season control of bittercress and oxalis was also obtained but these latter two weeds were starting to become troublesome at 10 weeks.

In 1989 studies, Gold Flame Spirea was injured with the same tablet herbicide combination (6) and in this study it was the only plant to show phytotoxicity symptoms (Table 1). The injury was not sufficient to visually reduce growth. This observation is significant because there were seven selections of herbaceous perennials that were completely tolerant on all sampling dates as indicated in Table 2. Nether metolachlor or oxyfluofen as commercial formulations are labelled for herbaceous plants, but combined into a slow-release tablet the anticipated phytotoxicity was not evident at any time.

Despite the success of reasonably good weed control and limited plant phytotoxicity, additional research is needed to continue to increase herbicide solubility from the tablet and to evaluate phytotoxicity on a wider spectrum of woody and herbaceous plants.

Summary

The objectives of this experiment were to evaluate weed control and phytotoxicity of a larger, softer slow-release herbicide tablet containing twice as much surfactant (2.0 percent) previous studies after a 10-week period.

Weed control was acceptable in all treatments for 10 weeks. There was no plant phytotoxicity on any evaluation date on 22 of the 23 plant selections evaluated including seven species of herbaceous perennials. Only Gold Flame Spirea was injured. Incorporating Goal and Pennant into a slow-release formulation appears to reduce the chances of phytotoxicity to landscape crops, based on studies in 1989 and 1990.

Table 1. Weed Control from Slow-Release Herbicide Tablets on Woody Landscape Plants.

Plant Materials	Size Cont.	No. Tablets/ Cont.	Weed Control[1] Dates 7/2	7/17	7/31	8/14	8/28
Elsie Lee	2 G	0	10.0	9.7	8.7	8.0	8.0
	2 G	2	10.0	10.0	9.7	9.7	9.7
Azalea	2 G	3	10.0	9.7	9.3	9.3	9.7
Hershey Red	1 G	0	10.0	9.3	9.3	9.3	8.7
	1 G	1	10.0	10.0	9.3	9.0	8.3
Azalea	1 G	2	10.0	10.0	9.7	9.0	8.7
Boulevard	2 G	0	10.0	7.7	6.7	7.0	6.7
	2 G	2	10.0	9.0	9.0	8.3	8.0
Chamaecyparis	2 G	3	10.0	9.7	9.3	8.7	8.7
Cranberry	1 G	0	10.0	10.0	9.0	8.7	8.0
	1 G	1	10.0	10.0	9.0	9.0	9.0
Cotoneaster	1 G	2	10.0	10.0	9.7	9.7	8.7
Royal Beauty	1 G	0	10.0	9.7	9.0	9.0	8.7
	1 G	1	10.0	10.0	9.7	9.3	9.3
Cotoneaster	1 G	2	10.0	10.0	9.7	9.7	9.7
Emerald Gaiety	1 G	0	10.0	10.0	9.3	8.7	7.3
	1 G	1	10.0	9.7	9.7	9.0	8.3
Euonymus	1 G	2	10.0	10.0	9.7	9.7	9.7
Emerald'N Gold	2 G	0	10.0	9.3	8.0	8.3	8.0
	2 G	2	10.0	9.7	9.7	9.7	9.0
Euonymus	2 G	3	10.0	9.7	10.0	10.0	9.7
Spring Glory	2 G	0	10.0	9.7	8.0	7.0	7.3
	2 G	2	10.0	10.0	9.3	8.3	8.3
Forsythia	2 G	3	10.0	10.0	10.0	9.3	8.7

(Continued)

Table 1. (Continued)

Plant Materials	Size Cont.	No. Tablets/ Cont.	Weed Control[1] Dates 7/2	7/17	7/31	8/14	8/28
Blue Princess	3 G	0	10.0	9.7	8.0	6.3	5.7
	3 G	3	10.0	10.0	9.3	9.0	8.3
Holly	3 G	4	10.0	10.0	9.7	9.3	8.3
Japgarden	1 G	0	10.0	9.3	7.7	7.3	7.0
	1 G	1	10.0	9.7	9.0	8.3	8.3
Juniper	1 G	2	10.0	10.0	9.0	8.7	8.7
Black Hills	1 G	0	10.0	9.0	8.7	7.7	6.7
	1 G	1	10.0	9.7	9.7	8.7	8.0
Spruce	1 G	2	10.0	9.7	9.3	9.0	8.7
Hoops Blue	3 G	0	10.0	8.7	6.7	6.0	5.0
	3 G	3	10.0	9.7	9.0	8.0	7.0
Spruce	3 G	4	10.0	9.7	9.3	7.7	7.3
Gold Flame	2 G	0	10.0	9.0	9.0	9.7	9.0
	2 G	2	10.0	10.0	9.7	9.7	9.7
Spirea	2 G	3	10.0	10.0	10.0	10.0	10.0
Hicks	1 G	0	10.0	7.7	5.7	5.7	5.3
	1 G	1	10.0	7.7	7.7	6.7	6.7
Taxus	1 G	2	10.0	9.3	9.0	8.3	8.0
Newport Red	2 G	0	10.0	9.7	9.3	9.0	9.3
	2 G	2	10.0	10.0	10.0	9.3	9.3
Weigela	2 G	3	10.0	10.0	10.0	10.0	10.0
Chinese	5 G	0	10.0	9.7	9.7	9.7	9.3
	5 G	4	10.0	10.0	10.0	10.0	10.0
Wisteria	5 G	5	10.0	9.7	9.7	10.0	10.0

[1]Weed Control=Visual Scale where 1=No Control, 7=Acceptable Control, and 10=No Weeds.

Table 2. Phytotoxicity from Slow-Release Herbicide Tablets on Woody Landscape Plants.

Plant Materials	Size Cont.	No. Tablets/ Cont.	Phytotoxicity[1] Dates 7/2	7/17	7/31	8/14	8/28
Elsie Lee	2 G	0	5.0	5.0	5.0	5.0	5.0
	2 G	2	5.0	5.0	5.0	5.0	5.0
Azalea	2 G	3	5.0	5.0	5.0	5.0	5.0
Hershey Red	1 G	0	5.0	5.0	5.0	5.0	5.0
	1 G	1	5.0	5.0	5.0	5.0	5.0
Azalea	1 G	2	5.0	5.0	5.0	5.0	5.0
Boulevard	2 G	0	5.0	5.0	5.0	5.0	5.0
	2 G	2	5.0	5.0	5.0	5.0	5.0
Chamaecyparis	2 G	3	5.0	5.0	5.0	5.0	5.0
Cranberry	1 G	0	5.0	5.0	5.0	5.0	5.0
	1 G	1	5.0	5.0	5.0	5.0	5.0
Cotoneaster	1 G	2	5.0	5.0	5.0	5.0	5.0
Royal Beauty	1 G	0	5.0	5.0	5.0	5.0	5.0
	1 G	1	5.0	5.0	5.0	5.0	5.0
Cotoneaster	1 G	2	5.0	5.0	5.0	5.0	5.0
Emerald Gaiety	1 G	0	5.0	5.0	5.0	5.0	5.0
	1 G	1	5.0	5.0	5.0	5.0	5.0
Euonymus	1 G	2	5.0	5.0	5.0	5.0	5.0
Emerald'N Gold	2 G	0	5.0	5.0	5.0	5.0	5.0
	2 G	2	5.0	5.0	5.0	5.0	5.0
Euonymus	2 G	3	5.0	5.0	5.0	5.0	5.0
Spring Glory	2 G	0	5.0	5.0	5.0	5.0	5.0
	2 G	2	5.0	5.0	5.0	5.0	5.0
Forsythia	2 G	3	5.0	5.0	5.0	5.0	5.0
Blue Princess	3 G	0	5.0	5.0	5.0	5.0	5.0
	3 G	3	5.0	5.0	5.0	5.0	5.0
Holly	3 G	4	5.0	5.0	5.0	5.0	5.0
Japgarden	1 G	0	5.0	5.0	5.0	5.0	5.0
	1 G	1	5.0	5.0	5.0	5.0	5.0
Juniper	1 G	2	5.0	5.0	5.0	5.0	5.0
Black Hills	1 G	0	5.0	5.0	5.0	5.0	5.0
	1 G	1	5.0	5.0	5.0	5.0	5.0
Spruce	1 G	2	5.0	5.0	5.0	5.0	5.0
Hoops Blue	3 G	0	5.0	5.0	5.0	5.0	5.0
	3 G	3	5.0	5.0	5.0	5.0	5.0
Spruce	3 G	4	5.0	5.0	5.0	5.0	5.0
Gold Flame	2 G	0	5.0	5.0	5.0	5.0	5.0
	2 G	2	5.0	4.7	4.7	5.0	5.0
Spirea	2 G	3	5.0	5.0	5.0	5.0	5.0
Hicks	1 G	0	5.0	5.0	5.0	5.0	5.0
	1 G	1	5.0	5.0	5.0	5.0	5.0
Taxus	1 G	2	5.0	5.0	5.0	5.0	5.0
Newport Red	2 G	0	5.0	5.0	5.0	5.0	5.0
	2 G	2	5.0	5.0	5.0	5.0	5.0
Weigela	2 G	3	5.0	5.0	5.0	5.0	5.0
Chinese	5 G	0	5.0	5.0	5.0	5.0	5.0
	5 G	4	5.0	5.0	5.0	5.0	5.0
Wisteria	5 G	5	5.0	5.0	5.0	5.0	5.0

[1]Phytotoxicity=Visual Scale where 1=Plant Death, 2=Severe Damage, 3=Moderate But Acceptable Damage, 4=Slight Damage and 5=No Damage.

Table 3. Weed Control and Phytotoxicity of Slow-Release Herbicide Tablets on Herbaceous Perennials.

Plant Materials	Size Cont.	No. Tablets/ Cont.	Weed Control Dates					Phytotoxicity Dates				
			7/2	7/17	7/31	8/14	8/28	7/2	7/17	7/31	8/14	8/28
Silver Mound	1 G	0	10.0	7.3	7.0	6.7	8.3	5.0	5.0	5.0	5.0	5.0
Artemisia	1 G	1	10.0	7.3	7.0	7.0	7.0	5.0	5.0	5.0	5.0	5.0
	1 G	2	10.0	9.7	9.3	9.3	9.3	5.0	5.0	5.0	5.0	5.0
Frickarti	1 G	0	10.0	7.3	7.3	7.7	7.3	5.0	5.0	5.0	5.0	5.0
Aster	1 G	1	10.0	9.7	9.3	9.0	8.7	5.0	5.0	5.0	5.0	5.0
	1 G	2	10.0	9.7	9.7	10.0	9.7	5.0	5.0	5.0	5.0	5.0
Coreopsis	1 G	0	10.0	9.7	8.7	8.3	8.3	5.0	5.0	5.0	5.0	5.0
Baby Sun	1 G	1	10.0	9.7	9.7	9.0	9.0	5.0	5.0	5.0	5.0	5.0
	1 G	2	10.0	9.7	10.0	10.1	9.7	5.0	5.0	5.0	5.0	5.0
Hosta	2 G	0	10.0	10.0	10.0	9.3	9.3	5.0	5.0	5.0	5.0	5.0
Antioch	2 G	2	10.0	10.0	10.0	10.0	10.0	5.0	5.0	5.0	5.0	5.0
	2 G	3	10.0	10.0	10.0	10.0	10.0	5.0	5.0	5.0	5.0	5.0
Liatrus	2 G	0	10.0	9.7	9.7	9.7	8.7	5.0	5.0	5.0	5.0	5.0
Spicata	2 G	2	10.0	10.0	10.0	10.0	9.7	5.0	5.0	5.0	5.0	5.0
	2 G	3	10.0	10.0	10.0	10.0	10.0	5.0	5.0	5.0	5.0	5.0
Rudbeckia	2 G	0	10.0	9.3	7.0	5.7	5.3	5.0	5.0	5.0	5.0	5.0
	2 G	2	10.0	10.0	9.3	8.7	8.0	5.0	5.0	5.0	5.0	5.0
Goldstrum	2 G	3	10.0	10.0	9.3	8.7	7.7	5.0	5.0	5.0	5.0	5.0
Yarrow	1 G	0	10.0	8.0	8.7	8.7	7.7	5.0	5.0	5.0	5.0	5.0
	1 G	1	10.0	9.7	9.7	9.3	9.3	5.0	5.0	5.0	5.0	5.0
	1 G	2	10.0	10.0	10.0	9.3	9.3	5.0	5.0	5.0	5.0	5.0

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A Two-Year Study of the Effectiveness of Gallery and Snapshot Herbicides in Container and Field Nurseries

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Abstract

The pre-emergence herbicides Gallery (isoxaben) Snapshot DF (isoxaben and oryzalin), and Snapshot G (isoxaben and trifluralin) were evaluated for efficacy and phytotoxicity of woody landscape plants produced in the field and in containers. The most effective product in both the containers and field was Snapshot DF at 3.0 and 4.0 lbs. aia. It was also the most injurious of the three herbicides, particularly on rooted cuttings of spirea and much less on one-year-old plants.

Introduction

A new pre-emergence herbicide with the common name of isoxaben and trade name of Gallery from Dow Elanco Products Co. controls broadleaved weeds extremely well. To control grasses and broadleaved weeds, isoxaben has been combined with Surflan and introduced as Snapshot DF. The combination of isoxaben with Treflan is known as Snapshot G.

Previous research has indicated that Snapshot is an effective pre-emergence herbicide that controls a wide spectrum of weeds including annual grasses and broadleaved weeds without appreciable injury to landscape plants (1,2). These studies, however, were limited to work with azalea, cotoneaster, euonymus, juniper and daffodils.

The objectives of this study were to evaluate efficacy and phytotoxicity on additional species and cultivars of woody landscape crops grown in both the field and in containers with multiple applications over two growing seasons.

Materials and Methods

Container Study

The herbicides utilized in this study were Gallery (common name-isoxaben) Snapshot DF (common name-isoxaben and oryzalin) and Snapshot G (a combination of isoxaben and trifluralin). The rates applied at each application were Gallery at 0.75 and 1.0 Snapshot DF at 3.0 and 4.0 and Snapshot G at 3.75 and 5.0 active ingredient per acre (aia). The herbicides were applied on June 3 and August 2, 1989 and on May 14 and July 15, 1990.

The plant materials included *Euonymus fortunnei* 'Emerald 'N Gold'—Emerald 'N Gold enonymus, *Forsythia intermedia* 'Spring Glory'—Spring Glory forsythia and *Spiraea* x *bumalda* 'Gold Flame'—'Gold Flame' spirea. The plants were produced from cuttings the previous year and were transplanted into two-gallon containers in a pine bark-peat-sand (6-3-1 by volume) medium on May 1, 1989. All plants were fertilized with Osmocote 18-6-12 and thoroughly irrigated.

Each treatment contained three, three plant replicates arranged in a randomized complete block design. The study was conducted in The Ohio State University research container nursery.

Containers were evaluated for weed control using a visual scale of 1-10 with 1=no weed control, 7=acceptable weed control and 10=perfect weed control. Phytotoxicity was evaluated similarly with 1=death of plants, 7=acceptable commercial injury and 10=no injury. Evaluations were conducted approximately every two weeks.

Field Study

The plants studied in the OSU Field research nursery included *Chamaecyparis pisifera* 'Boulevard'—Boulevard False cypress, *Euonymus fortunei* 'Emerald Gaiety'—Emerald Gaiety euonymous, and *Taxus media* 'Brownii'—Brown yew.

Herbicide treatments included Gallery at 1.0, Snapshot DF at 4.0, and Snapshot G at 5.0 lbs. aia. Treatments were applied in early spring with a retreatment in 60 days. Application dates in 1989 were June 3 and August 2, and in 1990 were May 15 and July 15. Each plot measured 10'×25' and contained at least three of each plant species. There were three replications of each treatment.

Plots were evaluated for weed control and phytotoxicity using the same visual scale as outlined above.

Results and Discussion

Containers

Weed control in containers was exceptional in 1989 (Table 1), and 1990 (Table 2) with the Snapshot DF treatment at 3.0 and 4.0 lbs aia throughout the evaluation period.

Gallery at 0.75 and 1.0 lb aia resulted in very good control both seasons, but particularly so in the first season. More than acceptable weed control was observed with Gallery for 16 weeks with a reapplication at eight weeks.

Snapshot G at 3.75 and 5.0 lbs aia was the least effective treatment both years with effectiveness decreasing at the eight week interval.

Field

In the field, the results were similar in respect to ranking herbicide effectiveness with Snaptshot DF extremely effective with one or two applications (Table 3). Gallery was not particularly effective in 1989, especially from the spring only application, however, in the second season weed control was much improved.

Snapshot G was effective for only four to six weeks in the field at 5.0 lbs aia. The second or early autumn application with all products definitely improved weed control as expected.

There was no phytotoxicity to euonymus or forsythia produced in containers from any herbicide in either year (Tables 4 and 5). Gold Flame spirea was damaged below acceptable levels during 1989 with Snapshot DF at both 3.0 and 4.0 lb rates (Table 4). There was very minor injury observed in 1989 with Gallery and Snapshot G. In 1990, only Snapshot DF injured the Spirea which was a one-year-old plant and more tolerant to herbicides than the rooted cuttings planted in 1989.

In summary, weed control is superior with Snapshot 80DF at 3.0 and 4.0 lbs aia in the field and container. There are some plants such as Gold Flame spirea which are sensitive to the herbicide and more studies will be needed to evaluate additional species and cultivars.

Gallery 75DF at 0.75 and 1.00 lb aia and Snapshot 2.5G at 3.75 and 5.0 lbs aia are most effective if two applications/season are applied. There is a greater margin of plant safety with these two compounds.

Table 1. Weed Control from Gallery and Snapshot in Container-Grown Nursery Crops—1989.

Treatment	Rate aia	Evaluation Dates 6/16	6/30	7/14	7/28	8/16	8/30	9/13	9/28
Control	——	10[1]	10	9.0	7.7	7.7	7.7	7.3	5.7
Gallery	0.75	10	10	10	10	10	10	10	10
75 DF	1.00	10	10	10	10	10	10	10	10
Snapshot	3.0	10	10	10	9.3	10	10	10	10
80 DF	4.0	10	10	10	10	10	10	10	10
Snapshot	3.75	10	10	9.0	7.7	10	9.3	8.0	6.3
2.5 G	5.0	10	10	9.0	7.7	9.7	7.7	7.3	8.0

[1]Visual Evaluation where 1=No Weed Control, 7=Acceptable Weed Control and 10=Perfect Weed Control.

Table 2. Weed Control from Gallery and Snapshot in Container-Grown Nursery Crops 1990.

Treatment	Rate aia	Weed Control Evaluation Dates 5/29	6/11	6/25	7/9	8/1	8/15	8/29
Control	——	8.3[1]	7.7	7.3	7.3	7.3	6.0	5.7
Gallery	0.75	10	10	9.7	9.7	9.7	9.0	8.0
75 DF	1.00	10	10	9.7	9.3	9.3	9.7	8.7
Snapshot	3.0	10	10	10	10	10	10	10
80 DF	4.0	10	10	10	10	10	10	10
Snapshot	3.75	8.3	7.7	7.3	7.3	7.3	6.7	6.0
2.5G	5.0	8.3	8.3	7.3	7.0	7.0	6.7	6.0

[1]Visual Evaluation where 1=Complete Death, 7=Acceptable Plant Injury and 10=No Plant Injury.

Table 3. Weed Control from Gallery and Snapshot in Field-Grown Nursery Crops in 1989 and 1990.

Weed Control—1989

Treatment	Treatment Season	Evaluation Dates 7/27	8/10	8/24	9/7	9/29	10/13	10/27
Control	——	9.3[1]	8.0	4.3	1.3	1.3	1.3	1.3
Gallery DF	Spring	9.7	8.7	7.3	5.7	3.7	3.7	3.7
Gallery DF	Spr/Aut	9.7	8.7	7.3	5.7	10	10	10
Snapshot DF	Spring	9.7	9.7	9.7	8.7	9.3	8.7	8.7
Snapshot DF	Spr/Aut	10	10	9.7	9.0	10	10	10
Snapshot G	Spring	9.7	8.3	6.7	4.0	2.3	1.7	1.7
Snapshot G	Spr/Aut	9.7	8.0	5.3	2.7	10	9.7	9.7

Weed Control—1990

Treatment	Season	Evaluation Dates 5/29	6/13	7/10	8/1	8/15	8/29
Control	——	5.3[1]	4.7	4.0	8.7	7.0	4.0
Gallery DF	Spring	9.0	8.0	7.7	9.0	8.7	7.3
Gallery DF	Spr/Aut	9.0	8.3	7.7	9.0	9.0	8.7
Snapshot DF	Spring	9.3	9.0	8.7	9.0	9.0	8.0
Snapshot DF	Spr/Aut	9.7	9.3	9.3	10	10	9.3
Snapshot G	Spring	8.7	7.7	7.0	8.3	7.3	5.7
Snapshot G	Spr/Aut	9.3	8.7	7.7	9.3	9.3	8.3

[1]Visual Evaluation where 1 = No Weed Control, 7 = Acceptable Weed Control and 10 = Perfect Weed Control.

Table 4. Phytotoxicity from Gallery and Snapshot in Container-Grown Nursery Crops—1989.

Plant Material	Treatment	Rate aia	Phytotoxicity Evaluation Dates 6/16	6/30	7/14	7/29	8/16	8/30	9/13	9/28
Euonymus	Control	——	10[1]	10	10	10	10	10	10	10
	Gallery	0.75	10	10	10	10	10	10	10	10
	75DF	1.00	10	10	10	10	10	10	10	10
	Snapshot	3.0	10	10	10	10	10	10	10	10
	80DF	4.0	10	10	10	10	10	10	10	10
	Snapshot	3.75	10	10	10	10	10	10	10	10
	2.5G	5.0	10	10	10	10	10	10	10	10
Forsythia	Control	——	10	10	10	10	10	10	10	10
	Gallery	0.75	10	10	10	10	10	10	10	10
	75DF	1.00	10	10	10	10	10	10	10	10
	Snapshot	3.0	10	10	10	10	10	10	10	10
	80DF	4.0	10	10	10	10	10	10	10	10
	Snapshot	3.75	10	10	10	10	10	10	10	10
	2.5G	5.0	10	10	10	10	10	10	10	10
Spirea	Control	——	10	10	10	10	10	10	10	10
	Gallery	0.75	10	9.3	9.7	9.7	9.0	9.3	9.3	9.7
	75DF	1.00	10	9.3	10	9.7	9.7	9.3	9.3	8.7
	Snapshot	3.00	8.7	6.3	6.3	7.0	6.7	6.0	6.0	7.3
	80DF	4.0	8.3	6.3	6.7	6.3	6.7	6.0	6.0	7.0
	Snapshot	3.75	10	10	9.7	10	10	10	10	10
	2.5G	5.0	10	9.3	9.3	9.7	9.7	9.3	8.7	9.3

[1]Visual Evaluation where 1=Complete Death, 7=Acceptable Plant Injury and 10=No Plant Injury.

Table 5. **Phytotoxicity from Gallery and Snapshot in Container-Grown Nursery Crops—1990.**

Plant Material	Treatment	Rate aia	Evaluation Dates						
			5/29	6/11	6/25	7/9	8/1	8/15	8/29
Euonymus	Control	——	10[1]	10	10	10	10	10	10
	Gallery	0.75	10	10	10	10	10	10	10
	75DF	1.00	10	10	10	10	10	10	10
	Snapshot	3.0	10	10	10	10	10	10	10
	80DF	4.0	10	10	10	10	10	10	10
	Snapshot	3.75	10	10	10	10	10	10	10
	2.5G	5.0	10	10	10	10	10	10	10
Forsythia	Control	——	10	10	10	10	10	10	10
	Gallery	0.75	10	10	10	10	10	10	10
	75DF	1.0	10	10	10	10	10	10	10
	Snapshot	3.0	10	10	10	10	10	10	10
	80DF	4.0	10	10	10	10	10	10	10
	Snapshot	3.75	10	10	10	10	10	10	10
	2.5G	5.0	10	10	10	10	10	10	10
Spirea	Control	——	10	10	10	10	10	10	10
	Gallery	0.75	10	10	10	10	10	10	10
	75DF	1.0	10	10	10	10	10	10	10
	Snapshot	3.0	10	10	10	10	10	9.3	9.3
	80DF	4.0	10	10	10	10	10	9.0	9.0
	Snapshot	3.75	10	10	10	10	10	10	10
	2.5G	5.0	10	10	10	10	10	10	10

[1]Visual Evaluation where 1=Complete Death, 7=Acceptable Plant Injury and 10=No Plant Injury.

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Evaluation of Flowering Crabapple Susceptibility to Apple Scab in Ohio—1990

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Abstract

Similar to the growing season of 1989, the months of April, May and June, 1990 were generally very wet and conditions were ideal for the growth and development of apple scab. In a survey of Ohio arboretums, 91 selections of flowering crabapple (Malus species and cultivars) were found to be resistant or highly resistant while 100 selections were susceptible or highly susceptible. By way of contrast, 1988 was a very dry season and the comparisons were 128 resistant and 82 susceptible.

Introduction

Apple scab caused by *Venturia inequalis* is a fungus disease which infects *Malus* species and cultivars. The disease is first manifested by olive gray spots on the foliage followed by yellowing and defoliation of susceptible selections of flowering crabapple. Continued defoliation will most likely weaken trees, reduce bloom in succeeding years and contribute towards greater winter injury.

Apple scab can be reduced or eliminated by planting resistant selections. The disease can be controlled by fungicides but this is a continual process requiring application every two weeks from late April until autumn.

The objective of this study was to evaluate flowering crabapples in Ohio arboretums for tolerance to apple scab. A statewide evaluation is valuable because it allows growers, retailers and landscapers to know which selections have proven to be resistant and which are susceptible to this disease of flowering crabapple in Ohio.

Materials and Methods

In August 1990, a survey of flowering crabapples was conducted in Ohio arboretums. Apple scab severity was rated and the presence of other diseases such as fireblight, cedar apple rust and frog eye leaf spot were also noted. Since the severity of the latter three diseases are usually not serious enough in Ohio to discontinue planting, ratings were not given.

The infestation of apple scab was rated as follows: HR=highly resistant—no indication of disease; R=resistant—mild infection with no defoliation; S=susceptible—medium infection with only slight defoliation; and HS=highly susceptible—heavy infection often accompanied by considerable defoliation of 25 percent or more.

More than one rating may appear in the table for a given selection as severity of infection varied among locations. The variation was most likely due to differences in time and amount of rainfall as well as average relative humidity.

Results and Discussion

Some degree of variability in apple scab exists from year to year based on previous observations by the authors (2, 3, and 4,). Rainfall between April and early July was well above normal in 1990.

In the survey there were 91 selections rated highly resistant or resistant while 100 were susceptible or highly susceptible. Comparing similar seasons there were 87 selections resistant and 106 susceptible in 1989 (3). In 1988, the most recent dry spring and summer, there were 89 selections resistant and 82 susceptible (4).

In 1990, among the most disease resistant selections to apple scab, fireblight, cedar apple rust and frog eye leaf spot were: *Malus* 'Beverly', 'Bob White', 'Centennial', 'Christmas Holly', 'David', 'Dolgo', *floribunda*, 'Golden Hornet', 'Golden Gem', 'Liset', 'Makamik', 'Mary Potter', *micromalus*, 'Ormiston Roy', 'Prairiefire', *prunifolia* 'Pendula', 'Red Jade', 'Red Jewel', *robusta* selections, *sargenti*, 'Selkirk', 'Sentinel', 'Strawberry Parfait', 'Sugartyme', *tschonoksi*, 'White Angel', *yunnanensis* selections and *zumi* 'Calocarpa'.

Flowering crabapples rated highly susceptible to apple scab in 1990 were: 'Almey', 'Amisk', *arnoldiana*, 'Arrow', 'Barbara Ann', 'Dorothea', 'Evelyn', 'Hopa', 'Katherine', 'Pink Flame', 'Pink Spires', 'Pink Weeper', 'Purple Wave', 'Eleyi', 'Radiant', 'Red Silver', and 'Tanner'. Due to the severity of apple scab this and in previous years (2, 3, 4) these selections should be discontinued from planting in Ohio.

To obtain information relative to cultural requirements and descriptions of recommended flowering crabapples consult the publication titled, "The Flowering Crabapple—A Tree For All Seasons" (1) available from county Extension Service offices.

Additional information can be obtained by visiting one of several arboretums in Ohio in late April—early May. Outstanding collections of flowering crabapples can be located in the Dawes Arboretum in Newark, Holden Arboretum in Kirkland Hills, the Secrest Arboretum in Wooster, and in other Ohio arboretums.

Table 1. Susceptibility of Flowering Crabapples to Apple Scab—1990.

Species, Hybrid or Cultivar	Apple Scab Rating				Other Diseases Noted
	HR	R	S	HS	
'Adams'			x	x	
M. x adstringens				x	
'Almey'				x	
'Amberina'				x	
'American Beauty'			x		
'Amisk'				x	
'Anne E'		x			
'Arnold Arboretum'			x		
M. x arnoldiana				x	
'Arrow'			x	x	
M. baccata		x			
M. baccata columnaris		x			
M. baccata 'Jacki'	x				
M. baccata 'Mandshurica'	x	x			
M. baccata 'Midwest'	x				
'Barbara Ann'				x	
'Beverly'	x				
'Blanche Ames'	x				
'Bob White'	x				
'Brandywine'		x	x		
M. brevipes				x	
'Burgundy'			x		
'Camelot'	x				
'Candied Apple'			x		
'Centennial'	x				
'Centurion'				x	
'Cheal's Crimson'			x		
'Chestnut'		x	x		
'Chilko'	x				
'Christmas Cheer'	x				
'Christmas Holly'	x				Fireblight
'Cinderela'		x	x		
'Coralburst'	x	x			Frog Eye Leaf Spot
M. coronaria 'Charlottae'		x	x		
M. coronaria 'Nieuwlandiana'			x		
'Cowichan'				x	
'Crimson Brilliant'				x	
'Dainty'				x	
'Dauphin'				x	
'David'	x	x			
'Dawsoniana'	x	x			
'Dolgo'	x				
'Donald Wyman'		x	x		
'Dorothea'				x	
'Dorothy Rowe'	x				
'Ellen Gerhart'				x	
'Evelyn'				x	
'Exzellenz Thiel'				x	
'Flame'				x	
'Flexilis'	x				

HR=Highly Resistant, R=Resistant, S=Susceptible, and HS=Highly Susceptible. (Continued)

Table 1. (Continued)

Species, Hybrid or Cultivar	Apple Scab Rating HR	R	S	HS	Other Diseases Noted
M. floribunda	x				
'Fusca'	x				
'Girard's Dwarf Weeping'		x			
'Geneva'			x		
'Goldfinch'				x	
M. glaucescens				x	
M. gloriosa			x	x	
'Golden Gem'	x				
'Golden Hornet'	x				Frog Eye Leaf Spot
'Gorgeous'			x		
'Gwendolyn	x				
M.halliana	x				
M. halliana 'Parkmanii'	x				
M. halliana 'Spontanea'	x				
'Hamlet'	x				
'Harvest Gold'				x	
'Henningi'			x	x	
'Henrietta Crosby'			x		
'Henry Dupont'			x		
'Hopa'				x	
'Hopa Austrian'				x	
'Hopa Dwarf'			x		
'Hopa Rosea'				x	
M. hupehensis	x				Fireblight
'Indian Magic'				x	Fireblight
'Indian Summer'				x	
M. ioensis	x				
M. ioensis 'Palmeri'	x				
M. ioensis 'Klehms'		x	x		
'Irene'				x	
'King Arthur'	x				
'Klehms Improved'		x	x		Cedar Apple Rust
'Jay Darling'				x	
'Joan'	x				
'Jewelberry'			x		
'Katherine'			x	x	
'Kibele'	x				
'Kirghisorum'	x				
'Lancelot'	x				
M. lancifolia				x	
'Leslie'		x	x		
'Liset'	x				
'Madonna'		x			
M. x magdeburgensis	x	x			
'Makamik'	x				
'Marshall Oyama'	x	x			
'Mary Potter'	x	x			
'Masek'	x	x			
M. x micromalus	x				
'Milton Barron'			x		
'Molton Lava'		x	x		

HR=Highly Resistant, R=Resistant, S=Susceptible, HS=Highly Susceptible. (Continued)

Table 1. (Continued)

Species, Hybrid or Cultivar	Apple Scab Rating HR	R	S	HS	Other Diseases Noted
'Neville Copeman'		x	x		
'Oakes'			x	x	
'Oekonomierat Echtermeyer				x	
'Oporto'			x		
'Ormiston Roy'	x				
Park Centre	x				
'Patricia'	x				
'Pink Beauty'		x			
'Pink Cascade'				x	
'Pink Dawn'		x	x		
'Pink Flame'				x	
'Pink Perfection'				x	
'Pink Weeper'				x	
'Prairie Rose'	x				
'Prairiefire'	x				
'Pretty Marjorie'		x			
'Prince Georges'				x	
'Profusion'			x	x	
'Prof. Sprenger'	x				Frog Eye Leaf Spot
M. prunifolia			x		
M. prunifolia 'Fastigiata'	x				
M. prunifolia 'Pendula'	x				
M. pumila 'Elise Rathke'			x	x	
M. pumila 'Niedzwetzkyana'				x	
M. pumila 'Paradise Foleus Aureus'	x				
'Purple Wave'				x	
M. purpurea				x	
M. purpurea 'Aldenhamensis'				x	Fireblight
M. purpurea 'Eleyi'				x	
M. purpurea 'Lemoinei'				x	
'Pygmy'			x		
'Radiant'				x	
'Ralph Shay'			x	x	
'Red Baron'			x	x	
'Red Edinburgh'				x	
'Red Flesh'			x		
'Red Jade'	x	x			Fireblight
'Red Jewel'	x	x			Fireblight
'Red Swan'	x				
'Red Silver'				x	
'Red Splendor'		x	x		Frog Eye Leaf Spot
'Ringo'			x		
'Robinson'				x	
M. x robusta	x	x			
M. x robusta 'Erecta'	x	x			
M. x robusta 'Leucocarpa'				x	
M. x robusta 'Persicifolia'	x				
'Rosseau'	x				
'Royal Ruby'				x	
'Royalty'			x		

HR=Highly Resistant, R=Resistant, S=Susceptible, and HS=Highly Susceptible. (Continued)

Table 1. (Continued)

Species, Hybrid or Cultivar	Apple Scab Rating HR	R	S	HS	Other Diseases Noted
'Ruby Luster'			x		
'Rudolf'			x		
M. sargentii	x				
M. sargentii 'Candymint'		x			
M. sargentii 'Rosea'		x	x		
M. sargentii 'Rose Low'	x				
M. x scheideckeri				x	
M. x scheideckeri 'Hilleri'		x	x		
'Selkirk'	x				Fireblight
'Sentinel'	x				
'Shakespeare'				x	
M. sieboldi	x				
M. sieboldi 'Arborescens'	x				
M. sieboldi 'Fuji'	x				
M. sikkimensis	x				
'Silver Moon'	x				Fireblight
'Simcoe'		x			
'Sinai Fire'	x				
'Sissipuk'	x				Frog Eye Leaf Spot
'Snowcloud'		x	x		
'Snowdrift'				x	
'Snowmagic'				x	
M. x soulardii		x	x		
'Sparkler'				x	
M. spectabilis			x	x	
M. spectabilis 'Albi-Plena'				x	
M. spectabilis 'Riversi'	x	x			
M. spectabilis 'Van Eseltine'		x	x		Fireblight
'Spring Snow'				x	
'Spring Song'	x				
'Strathmore'				x	
'Strawberry Parfait'	x				
M. x sublobata	x	x			
'Sugartyme'	x	x			Fireblight
'Sundog'	x				
M. sylvestris 'Plena'	x	x			
'Tanner'				x	
M. toringoides			x		
M. toringoides 'Macrocarpa'			x		
'Trail'	x				
M. tschonoski	x				
'Turesi'				x	
'Valley City #4'				x	
'Vanguard'				x	
'Veitchs Scarlet'	x				Fireblight
'Velvet Pillar'				x	
'Wabiskaw'				x	
'White Angel'	x				
'White Candle'				x	
'White Cascade'		x	x		
'Wilson'				x	

HR = Highly Resistant, R = Resistant, S = Susceptible, HS = Highly Susceptible. (Continued)

Table 1. (Continued)

Species, Hybrid or Cultivar	Apple Scab Rating HR	R	S	HS	Other Diseases Noted
'Winter Gold'				x	
'Wooster No. 1'	x				
M. yunnanensis 'Veitchi'	x				Fireblight
M. zumi				x	
M. zumi 'Calocarpa'		x			
M. zumi 'Rang'	x				

HR=Highly Resistant, R=Resistant, S=Susceptible, HS=Highly Susceptible.

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A Comparison of Slow-Release Fertilizers for the Nursery Industry

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Abstract

Ten slow-release fertilizers at three rates were evaluated on container-grown azalea, cotoneaster and euonymus. Plant growth was acceptable with all treatments. The most consistent growth was observed in plants fertilized with nutricote followed by plants in Osmocote treatments. Plant growth in treatments at 2.0 and 2.5 lbs. N/cu. yd. was as good as plants in the 3.0 lb. treatments.

Introduction

Most container nurseries in Ohio and in the northeastern U.S. have developed a fertilizer program based on slow-release fertilizers. Soluble fertilizers are used as a supplement when additional nitrogen is required early in the season or when higher potassium is required later in the growing season (1). Soluble fertilizers are also utilized to provide single element supplements, especially iron (2).

The slow-release fertilizers have proven successful in the pine-bark based media that has become the growers' choice in recent years throughout the eastern U.S.

Within the last two to three years new fertilizer products have become commercially available in Ohio such as Nutricote and Woodace while others such as Sref II, Prokote and Osmocote have been modified. The objectives of this study were to compare plant growth as a function of selected new and improved slow-release fertilizers.

Materials and Methods

The fertilizer trial was conducted in The Ohio State University research nursery in Columbus, Ohio.

The fertilizers in the study included: Osmocote 18-6-12, Osmocote 18-7-12, Woodace 20-4-11, Woodace 18-8-9, Woodace 22-7-4, Nutricote 16-10-10, Nutricote 20-7-10, Nutricote 18-6-8, Sref II 20-4-10 and Prokote 20-3-10. Each fertilizer treatment was applied as a top dress application, at rates of either 2.0, 2.5, or 3.0 pounds of actual nitrogen per cubic yard.

The plants were all potted into one-gallon containers in a medium of pinebark—peat—sand 6:3:1 by volume. The plants were fertilized on June 15, 1989.

The plant materials were *Rhododendron* 'Elsie Lee'—Elsie Lee azalea, *Cotoneaster apiculata*—Cranberry cotoneaster and *Euonymus fortunei* Emerald 'N Gold—Emerald 'N Gold euonymus.

There were three replications of all treatments with three plants per treatment for a total of 810 plants located in a randomized block design.

Plants were watered, pruned and treated for pests as for commercial nursery practices.

Plants were measured for vegetative growth, and harvested for dry weight at the end of the growing season.

Results and Discussion

The data for the season's growth of azalea as a function of height and width divided by 2 is shown along with the dry weight in Table 1. The largest dry weights were recorded in the Nutricote 20-7-10 treatments at all three fertilizer rates. The next highest and most consistent rates were noted in the Nutricote 18-6-8 treatment.

The growth of cranberry cotoneaster, as shown in Table 2, was highest on a dry weight basis in Nutricote 16-10-10 at 2.5 lbs/cu.yd., Osmocote 18-6-12 at 2.5 lbs/cu. yd., and Nutricote 18-6-8 at 3.0 lbs/cu. yd.

Emerald 'N Gold euonymus grew well in most all fertilizer treatments although the greatest dry weight was from the treatments of Nutricote 20-7-10 at 2.0 lbs N/cu. yd. and Osmocote 18-7-12 at 2.0 lbs N/cu. yd., as shown in Table 3.

From an overall perspective with all three species plant growth was acceptable with all treatments. Under the conditions of this study, however, the plants in the Nutricote treatments were usually very strong followed by plants in the Osmocote treatments. As expected, there were species differences in response to fertilizer treatments and due to this and the management practices in our nursery the authors encourage growers to run similar studies in their nurseries.

In general, a 3.0 lb. N rate/cu. yd. is higher than normal for most container crops. In this study, there was no phytotoxicity from any fertilizer on any plant. There was equally good growth, however, at both 2.0 and 2.5 lb rates with most fertilizers as there was with the 3.0 lb. rate. Even though the 3.0 rate was not phytotoxic it represented more than was required and should be considered as a waste of fertilizer.

Summary

Growth of azalea, cotoneaster and euonymus was compared as a function of 10 slow-release fertilizers at three rates. In general, plant growth was more consistent in containers treated with Nutricote and Osmocote fertilizer formulations, even though there was plant response variations. Growers are urged to conduct similar trials comparing their fertilizer products with some of these new formulations which represent improvements over earlier formulations.

Table 1. Season Growth and Dry Weight of Azalea.

		Season Growth (cm)	Dry Weight (g)
Osmocote 18-6-12	2.0	27.89abcdef	29.90cdef
	2.5	26.39def	24.45efg
	3.0	26.61cdef	25.93efg
Osmocote 18-7-12	2.0	28.00abcdef	29.12cdefg
	2.5	26.89bcdef	27.91efg
	3.0	25.22f	22.84efg
Woodace 18-8-9	2.0	27.78abcdef	25.23efg
	2.5	25.39f	23.35efg
	3.0	28.17abcdef	26.20efg
Woodace 20-4-11	2.0	26.22ef	23.91efg
	2.5	28.83abcdef	26.24efg
	3.0	29.28abcdef	24.86efg
Woodace 19-6-10	2.0	25.94ef	23.76efg
	2.5	26.44def	27.11efg
	3.0	26.28ef	28.71defg
Sref II 20-4-10	2.0	25.06f	21.42fg
	2.5	25.17f	20.54g
	3.0	26.11ef	20.71g
Nutricote 16-10-10	2.0	32.11a	29.12cdefg
	2.5	29.39abcdef	37.52abc
	3.0	26.22ef	25.67efg
Nutricote 18-6-8	2.0	31.67abc	42.91a
	2.5	31.44abcd	36.87abcd
	3.0	30.61abcde	37.18abcd
Nutricote 20-7-10	2.0	30.67abcde	42.58a
	2.5	31.78ab	43.61a
	3.0	32.78a	39.97a
Prokote 20-3-10	2.0	27.72abcdef	30.76bcde
	2.5	28.67abcdef	26.43efg
	3.0	29.17abcdef	30.95bcde
LSD at 5%			

Table 2. Season Growth and Dry Weight of Cotoneaster.

		Season Growth (cm)	Dry Weight (g)
Osmocote 18-6-12	2.0	38.61a	34.85cdefghi
	2.5	36.83abcd	44.79ab
	3.0	34.78abcdefg	37.85abcdefgh
Osmocote 18-7-12	2.0	34.56abcdefg	37.71abcdefgh
	2.5	32.61cdefgh	35.28abcdefghi
	3.0	35.78abcde	41.09abcde
Woodace 18-8-9	2.0	32.94cdefgh	29.10ij
	2.5	35.06abcdefg	35.86cdefghi
	3.0	35.33abcdefg	42.27abcd
Woodace 20-4-11	2.0	33.50bcdefgh	30.22hij
	2.5	33.17cdefgh	31.04ghij
	3.0	31.50efghi	33.28efghij
Woodace 19-6-10	2.0	31.89efgh	29.55ij
	2.5	32.22defgh	35.49cdefghi
	3.0	31.06fghi	31.58ghij
Sref II 20-4-10	2.0	27.06i	18.02k
	2.5	29.05hi	26.09j
	3.0	31.67efghi	32.43fghij

(Continued)

Table 2. (Continued)

		Season Growth (cm)	Dry Weight (g)
Nutricote 16-10-10	2.0	34.33abcdefg	41.36abcd
	2.5	34.89abcdefg	45.07a
	3.0	34.83abcdefg	42.87abc
Nutricote 18-6-8	2.0	37.00abcdefg	36.78bcdefghi
	2.5	34.50abcdefg	37.05abcdefghi
	3.0	37.94ab	44.22ab
Nutricote 20-7-10	2.0	34.61abcdefg	39.85abcdef
	2.5	35.67abcdef	39.09abcdefg
	3.0	37.00abc	40.66abcde
Prokote 20-3-10	2.0	30.72ghi	34.15defghi
	2.5	34.89abcdefg	34.89cdefghi
	3.0	31.56efghi	30.53hij
LSD at 5%			

Table 3. Season Growth and Dry Weight of Eyonymus.

		Season Growth (cm)	Dry Weight (g)
Osmocote 18-6-12	2.0	22.06d	13.97cdefghi
	2.5	27.50abc	16.83abcd
	3.0	25.17abcd	17.96abc
Osmocote 18-7-12	2.0	25.56abcd	18.82ab
	2.5	24.11abcd	14.21cdefghi
	3.0	24.33abcd	15.42abcdef
Woodace 18-8-9	2.0	27.39abc	14.16cdefghi
	2.5	26.39abcd	14.78abcdefghi
	3.0	25.33abcd	14.06cdefghi
Woodace 20-4-11	2.0	24.89abcd	14.01cdefghi
	2.5	24.78abcd	11.44fghi
	3.0	25.78abcd	15.48abcdef
Woodace 19-6-10	2.0	25.83abcd	15.24abcdefg
	2.5	24.72abcd	13.43defghi
	3.0	23.22cd	14.92abcdefghi
Sref II 20-4-10	2.0	22.22d	12.01fghi
	2.5	23.06cd	10.98ghi
	3.0	22.67cd	10.57i
Nutricote 16-10-10	2.0	24.11abcd	14.56bcdefghi
	2.5	25.22abcd	16.56abcd
	3.0	24.61abcd	16.45abcde
Nutricote 18-6-8	2.0	26.22abcd	14.38cdefghi
	2.5	26.06abcd	15.07abcdefgh
	3.0	28.67a	15.37abcdefg
Nutricote 20-7-10	2.0	28.44ab	19.06a
	2.5	26.00abcd	14.37cdefghi
	3.0	23.61bcd	12.10efghi
Prokote 20-3-10	2.0	26.61abcd	10.94hi
	2.5	28.33ab	15.32abcdefgh
	3.0	28.17ab	14.83abcdefghi
LSD at 5%			

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Application of Composted Municipal Sludge in the Landscape

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Abstract

The specific objectives were to evaluate growth of plants produced in composted municipal sludge (CMS) amended mineral soil. The CMS was from the city of Akron and marketed as TechnaGro. The CMS was used as a soil additive, as a mulch and as a combination of both. The best treatment was 1.5″ incorporated with 2.0″ mulch. Mulch levels over 2.0″ were unfavorable. CMS was valuable for the production of begonia, chrysanthemum, dahlia, gomphrena, marigold, periwinkle and salvia. Aster, geranium and petunia did not respond well in compost incorporated into the soil or used as a mulch.

Introduction

Composted municipal sludge from several U.S. cities has been available for use by the horticulture industry for approximately 10 years. Numerous research studies have shown its value as a media amendment for production of container grown landscape plants (1,2,3,4,5,6,7,8,9). There have been no published reports of research with CMS as a supplement to landscape or field sites for the production of landscape crops.

With CMS becoming more readily available in Ohio to the landscaping industry it seemed appropriate to examine this product as both a soil conditioner and mulch. The specific objectives were to evaluate growth of plants produced in CMS from the city of Akron, marketed under the name of TechnaGro. The CMS product was: 1) incorporated as a soil conditioner into mineral soil; 2) applied as a mulch; and 3) as a combination soil conditioner and mulch.

Materials and Methods

The study was conducted in Brookston silt loam soil in the research nursery on the campus of The Ohio State University. Treatments were as follows: CMS incorporated at depths of 0.5″, 1.0″ and 1.5″, CMS mulched at depths of 2.0″, 3.0″ and 4.0″, and the combination of incorporated depths of 0.5″, 1.0″ and 1.5″ each with 2.0″ of mulch. The incorporated treatments were all rototilled into the soil at a depth of 4.0″ giving percentages of soil conditioner as 10, 20 and 30. Each treatment measured 10′ × 30′. Across each treatment were planted 10 rows of annual flowers.

The species and cultivars of annuals grown included Pixie Princess Mix aster, Prelude Mix begonia, Fiesco dahlia, Razzmatazz geranium, Little Buddy gomphrena, Golden Gate marigold, Allure chrysanthemum, Little Bright Eyes periwinkle, Cascade Mix petunia and Rhea salvia.

The treatments were applied during the first week of July in 1989. Annuals were planted and watered on July 11, 1989. Additional fertilizers were not added to any of the plots in order to avoid increasing the soluble salts level.

On September 19, 1989, approximately nine weeks after planting, plants were cut at the base, dried and weights obtained. Foliar samples for mineral analysis were taken of Vinca and Geranium. Soil samples were taken from each treatment.

Results and Discussion

The dry weight of each of the species and cultivars of annuals grown in the 10 treatments are presented in Table 1.

Aster grew best in plots with little or no CMS. The greater growth occurred in plots with 0.5" and in the check plot. Aster was definitely sensitive to composted municipal sludge.

Begonia responded positively to all treatments with significant growth increases in all nine treatments when compared to untreated control plots.

Dahlia, like begonia, responded positively to all treatments with significant growth increases in all mulch and soil conditioner plots when compared to control plots.

Geranium, like aster, did not grow as well in the compost treatments. Although the greatest growth was in the 1.0″ incorporated plot the next best treatment was the control followed by the 0.5″ incorporated treatment. The foliage showed symptoms of marginal browning or yellowing in most all the compost treatments throughout most of the summer.

Gomphrena responded positively to all the compost treatments and there were significant growth differences from all treatments when compared to untreated controls. The best growth occurred in the combination treatment of 1.5″ inc. plus 2.0″ mulch.

Marigold responded most favorably to incorporated treatments of 1.0″ and 1.5″ and each of the three incorporated treatments with 2″ of mulch. High rates of mulch of 3.0″ and 4.0″ did not result in increased growth when compared to controls.

Chrysanthemum plants exhibited marginal chlorosis soon after planting particularly in the 3″ and 4″ mulch plots. Best growth of mums occurred in the incorporated treatments and those receiving 2″ of mulch.

Periwinkle grew extremely well in most compost or mulch treatments. The least vegetative growth occurred in the control plot and the 0.5″ inc. treatment.

Petunia growth was inconsistent in the compost treatments. The best growth occurred in the 1.5″ inc. plot and the next best treatments were 1.0 inc. with 2.0″ mulch and control plots. The mulch only treatments were of no value to petunia growth.

Salvia growth was best in the 1.5″ inc. with 2.0″ mulch treatment. The next best treatments were 1.0″ inc. plus 2.0″ mulch and 0.5″ inc. plus 2.0″ mulch. The 3″ and 4″ mulch treatments were not especially beneficial.

Table 1. The dry weight, in grams, of annuals grown in Akron composted municipal sludge used as a soil conditioner and/or mulch. Plants harvested September 1989.

Treatment	Aster	Chrysanthemum	Geranium	Petunia	Dahlia
Check	13.90ab	49.32e	44.81b	71.73ab	33.48f
4″ Akron Mulch	4.24d	49.80e	18.22f	51.26e	43.96e
3″ Akron Mulch	9.09bcd	63.67d	23.69ef	52.22de	48.04e
2″ Akron Mulch	12.25abc	77.72c	32.99cd	54.33cde	57.39d
1.5 Inc +2″ M	12.99abc	89.71ab	32.47cd	60.84bcd	58.68d
1.0 Inc +2″ M	10.98bc	83.66b	20.49ef	73.08ab	64.01c
.5 Inc +2″ M	8.20cd	77.89c	27.43de	67.57bc	82.99b
1.5 Inc	12.40abc	92.10a	32.13cd	80.90a	96.79a
1.0 Inc	12.87abc	92.86a	55.70a	65.46bcd	72.69c
.5 Inc	16.84a	82.13bc	38.53bc	56.46cde	48.49e
LSD=.05	4.937	7.31	7.364	13.373	8.057

Treatment	Gomphrena	Salvia	Begonia	Marigold	Vinca
Check	7.06d	18.66e	29.17d	83.14c	30.76f
4″ Akron Mulch	16.33c	22.74e	45.25a	87.80c	45.08cd
3″ Akron Mulch	25.56b	27.90cde	35.03cd	87.04c	42.55de
2″ Akron Mulch	30.23ab	33.96cd	43.75ab	100.36ab	51.81bc
1.5 Inc +2″ M	34.55a	60.15a	45.48a	107.03ab	54.55b
1.0 Inc +2″ M	29.87ab	50.96ab	37.28bc	117.24a	70.82a
.5 Inc +2″ M	29.83ab	48.08b	40.88ab	105.95ab	47.21bcd
1.5 Inc	26.95ab	36.39cd	44.43a	112.39a	43.94cde
1.0 Inc	30.25ab	36.46c	35.77c	111.06a	46.94bcd
.5 Inc	28.81ab	26.49d	44.31a	89.07bc	35.71ef
LSD=.05	7.683	9.942	6.528	19.01	9.04

In summary, seven species responded favorably to the compost treatments although at least three of the 10 did not show consistent positive growth. Aster, geranium and petunia did not do particulary well in the compost treatments. Species response was anticipated and represented the reason that 10 selections of annuals were used in the trial. Based on this study CMS could be valuable for the production of begonia, dahlia, gomphrena, marigold, chrysanthemum, periwinkle and salvia.

Overall, the best treatments for plant growth were the incorporated treatments with mulch. The 1.5″ inc. with 2.0″ mulch was a good treatment across most species.

Clearly, the rates of mulch above 2.0″ were not particularly effective in promoting additional growth.

Foliar analysis data was taken from one species, Vinca, that grew well in compost treatments, and another, geranium that did not grow particularly well in the compost. The nitrogen, phosphorus and potassium data from plants in each treatment are shown in Table 2. Generally, the highest levels of each of the three elements of both species occurred in the incorporated treatments with the 2.0″ of mulch.

The soil data for pH, phosphorus, potassium, calcium, magnesium, soluble salts and cation exchange capacity are presented in Table 3. The pH remained relatively stable from 5.6 to 6.4 between treatments. The pH of the untreated soil was 6.1 and the compost 6.6. Soil phosphorus was highest in the 1.5″ inc. and 2.0″ mulch treatment. Soil potassium was generally highest in the mulch plots. Soil CEC was not higher than control treatments even though the composted municipal sludge was higher than the soil. The soluble salts level was quite high in the composted municipal sludge (315) and all treatments were higher than the control treatment (15.67).

Work will continue in 1990 to determine the effect of two years incorporated and mulch treatments of Akron Composted municipal sludge on similar species of annual flowers.

Table 2. Foliar analysis of vinca and geranium harvested in September 1989 following 9 weeks of growth in Akron composted municipal sludge used as a soil conditioner and/or mulch. Value expessed in percentage.

	Vinca			Geranium		
Treatment	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
check	2.35c	0.2512d	1.3730f	2.10d	0.2456de	1.4454c
4″ Mulch	2.48c	0.2813cd	1.7190bc	2.85b	0.2707cd	2.5563a
3″ Mulch	2.85b	0.2633cd	1.6611cd	2.75bc	0.2828bc	1.6320bc
2″ Mulch	2.85b	0.2728cd	1.5153de	2.99a	0.2972bc	2.1407ab
1.5 Inc. +2″ Mulch	3.43a	0.3581a	1.7944bc	2.93ab	0.3023ab	2.4178a
1.0 Inc. +2″ Mulch	3.66a	.3367a	.0324a	3.10a	0.3245a	2.5725a
.5 Inc. +2″ Mulch	3.70a	0.3365a	2.0133a	3.00a	0.2843bc	2.4883a
1.5 Inc.	3.77a	0.3273cb	1.9242ab	2.64c	0.2355e	2.1293ab
1.0 Inc.	3.42a	0.2982bc	1.5846dc	2.65c	0.2438de	2.1716ab
.5 Inc.	2.41c	0.2930bc	1.4730ef	2.21d	0.2423e	1.5808bc
LSD=.05	.348	0.36865	.2074536	.203	0.270657	.702062

Table 3. Soil Analysis from Akron Composted Municipal Sludge Taken September 26 or 10 Weeks after Application.

	pH	P	K	Ca	Mg	CEC	SS
check	6.13ab	350.33bc	241.33cd	4003abc	750a	15.33ab	15.67e
4″ Mulch	6.27ab	170.67bc	346.67a	4283ab	738a	16.00a	25.67d
3″ Mulch	5.90bc	135.67c	301.33ab	3653bc	630b	15.33ab	27.67cd
2″ Mulch	5.63c	155.00bc	240.67cd	3447c	539bc	15.00ab	25.67d
1.5 I +2″ Mulch	6.50a	674.00a	322.00ab	4633a	445d	14.67bc	34.33c
1.0 I +2″ Mulch	6.23ab	441.33b	320.67ab	3687bc	401d	13.67cd	28.33cd
.5 I +2″ Mulch	6.13ab	372.67bc	284.bc	3377c	406d	13.00de	32.33cd
1.5 Inc.	6.17ab	450.33b	291.67b	3840bc	482cd	12.33e	62.33a
1.0 Inc.	6.30ab	272.33bc	233.67d	3523c	482cd	12.33e	51.00b
.5 Inc.	6.47a	225.33bc	197.33d	3520c	553bc	12.00e	32.33cd
Akron Mulch	6.63	1754.67	1311.00	6276	534	19.67	315.33
LSD=.05	.457	300.45	47.31	729.34	93.92	1.30	7.35

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Composted Municipal Sludge from Two Ohio Cities for Container-Grown Woody Ornamentals

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Abstract

This study was undertaken to determine the effectiveness of composted municipal sludge (CMS) from two Ohio cities as an amendment to media used to produce container-grown nursery stock. A 10 percent amendment was sufficient. Additional supplements of 20 and 30 percent were not superior. However, the best treatment for azalea, euonymus and rudbeckia was pinebark — Akron CMS—sand at 6-3-1 by volume. CMS from Akron can be used to replace peat in the media, however, CMS from Hamilton cannot be used to replace peat.

Introduction

Most container-grown woody ornamentals produced commercially in Ohio are grown in either a pine bark and/or hardwood bark media. Additional supplements include peatmoss, haydite, sand and various composts depending on availability. Research has proven the superior qualities of both hardwood and pinebark for growth of container plants (1-8).

As municipal waste products become more available there is interest in determining whether there might be an application in producing nursery crops. Composted municipal sludge from Ohio cities is now available in the trade and has been used with some success in containers.

The objective of this research was to evaluate growth of plants produced in composted municipal sludge amended media from two Ohio sources. The city of Akron has been selling CMS under the name "Techna Gro" for several years while the city of Hamilton will be offering CMS to the trade soon. The specific objectives were 1) to compare various rates of CMS in 14 different combinations of pine bark or hardwood bark media, and 2) to determine if composted municipal sludge could replace peat in the medium. The advantage to this substitution would represent a savings to the producer as peat is imported from Canada and is expensive.

Materials and Methods

The treatments and rates by volume were as follows:

Pinebark	Peat	Sand		6-3-1
Hardbark	Peat	Sand		6-3-1
Pinebark	Akron CMS	Sand		6-3-1
Pinebark	Akron CMS	Peat	Sand	6-2-1-1
Pinebark	Akron CMS	Peat	Sand	6-1-2-1
Pinebark	Hamilton CMS	Sand		6-3-1
Pinebark	Hamilton CMS	Peat	Sand	6-2-1-1
Pinebark	Hamilton CMS	Peat	Sand	6-1-2-1
Hardbark	Akron CMS	Sand		6-3-1
Hardbark	Akron CMS	Peat	Sand	6-2-1-1
Hardbark	Akron CMS	Peat	Sand	6-1-2-1
Hardbark	Hamilton CMS	Sand		6-3-1
Hardbark	Hamilton CMS	Peat	Sand	6-2-1-1
Hardbark	Hamilton CMS	Peat	Sand	6-1-2-1

The compost from both Akron and Hamilton were used at 10, 20 and 30 percent which reduced the peatmoss from 30 to 20, 10 and 0 percent in both pinebark and hardwood bark media. The sand was kept constant at 10 percent and the bark sources at 60 percent.

The woody plant materials were Hershey Red azalea and Emerald 'N Gold euonymus and the herbaceous perennial was *Rudbeckia* 'Goldstrum'—Goldstrum rudbeckia.

There were three plants per treatment and three replications arranged in a randomized block design.

The plants were containerized on May 18, 1990, fertilized with Sierrablend 17-6-10 and irrigated as for commercial nursery conditions. The media pH at the beginning of the experiment is shown in Table 1. Plants were harvested at the soil line on September 4, 1990, dried in ovens and weighed.

Results and Discussion

The best growth of all three plant species occurred in pinebark — Akron composted municipal sludge—Sand (6-3-1 by volume) media (Table 2). Excellent plant growth was also observed in pinebark—Akron Composted municipal sludge—peat—sand at 6-1-2-1 and 6-2-1-1 by volume.

In general, plants grew better in pinebark vs. hardwood bark media. Plants grew better in CMS-amended media and a 10 percent supplement was as good or better than higher rates. Plants grown in media without CMS weighed on the average 29.1 grams, while 10 percent CMS resulted in plants of 35 grams, 20 percent and 30 percent=32 grams.

Can peat moss be replaced by CMS? Akron CMS can replace peat in pinebark media of Euonymus and Rudbeckia but not azalea which requires the low pH of peat. Akron CMS can replace peat in hardwood media in azalea and euonymus but not rudbeckia. Hamilton CMS cannot be used to replace peat in either pinebark or hardbark media.

Azalea growth was best in the following media in decreasing order:

Pinebark	Akron CMS	Sand		6-3-1
Pinebark	Akron CMS	Peat	Sand	6-1-2-1
Hardbark	Akron CMS	Sand		6-3-1
Pinebark	Hamilton CMS	Peat	Sand	6-1-2-1
Pinebark	Akron CMS	Peat	Sand	6-2-1-1
Hardbark	Akron CMS	Peat	Sand	6-2-1-1
Pinebark	Hamilton CMS	Sand		6-3-1

Euonymus growth was best in:

Pinebark	Akron CMS	Sand		6-3-1
Pinebark	Akron CMS	Peat	Sand	6-1-2-1
Pinebark	Akron CMS	Peat	Sand	6-2-1-1
Pinebark	Hamilton CMS	Peat	Sand	6-1-2-1

Rudbeckia grew best in:

Pinebark	Akron CMS	Sand		6-3-1
Pinebark	Akron CMS	Peat	Sand	6-2-1-1
Hardbark	Akron CMS	Peat	Sand	6-1-2-1
Pinebark	Akron CMS	Peat	Sand	6-1-2-1
Pinebark	Hamilton CMS	Peat	Sand	6-1-2-1
Hardbark	Akron CMS	Peat	Sand	6-2-1-1
Hardbark	Peat	Sand		6-3-1
Hardbark	Akron CMS	Sand		6-3-1

There was no observable damage to plants from any of the CMS treatments.

Summary

Azalea, euonymus and rudbeckia grew very well in Pinebark-Akron CMS-Sand and Pinebark-Akron CMS-Peat-Sand media. Overall, a 10 percent CMS supplement was as good as 20 or 30 percent and pinebark was better than hardbark as the primary ingredient. Akron CMS was effective in four of six instances in replacing peat but Hamilton CMS was not effective in replacing peat.

Table 1. The pH of Composted Municipal Sludge Amended Container Media Treatments. Samples taken May 30, 1990.

Treatment	Ratio	Media pH
Pinebark/Peat/Sand	6-3-1	4.2 i
Hardbark/Peat/Sand	6-3-1	5.6 f
Pinebark/Akron CMS/Sand	6-3-1	6.3 de
Pinebark/Akron CMS/Peat/Sand	6-2-1-1	6.2 e
Pinebark/Akron CMS/Peat/Sand	6-1-2-1	5.4 g
Pinebark/Hamilton CMS/Sand	6-3-1	6.5 c
Pinebark/Hamilton CMS/Peat/Sand	6-2-1-1	6.2 e
Pinebark/Hamilton CMS/Peat/Sand	6-1-2-1	5.1 h
Hardbark/Akron CMS/Sand	6-3-1	6.7 b
Hardbark/Akron CMS/Peat/Sand	6-2-1-1	6.8 b
Hardbark/Akron CMS/Peat/Sand	6-1-2-1	6.7 b
Hardbark/Hamilton CMS/Sand	6-3-1	7.1 a
Hardbark/Hamilton CMS/Peat/Sand	6-2-1-1	7.1 a
Hardbark/Hamilton CMS/Peat/Sand	6-1-2-1	6.8 b
LSD at .05		.16
Akron CMS only	10	6.7
Hamilton CMS only	10	7.3

Table 2. Dry Weight of Landscape Crops Produced in Composted Municipal Sludge Amended Container Media.

		Dry Weight In Grams		
Treatment	Ratio	Azalea	Euonymus	Rudbeckia
P.bark/Peat/Sand	6-3-1	21.7 abz	4.21 efg	59.3 de
H.bark/Peat/Sand	6-3-1	14.2 ef	3.2 g	72.0 abcd
P.bark/A.CMS/Sand	6-3-1	23.8 a	11.6 a	87.7 a
P.bark/A.CMS/Peat/Sand	6-2-1-1	21.5 ab	10.4 ab	86.5 a
P.bark/A.CMS/Peat/Sand	6-1-2-1	23.7 a	11.3 a	80.9 ab
P.bark/H.CMS/Sand	6-3-1	19.1 abcd	5.2 efg	53.9 e
P.bark/H.CMS/Peat/Sand	6-2-1-1	18.8 bcde	8.3 bcd	59.3 de
P.bark/H.CMS/Peat/Sand	6-1-2-1	23.4 ab	9.1 abc	79.7 abc
H.bark/A.CMS/Sand	6-3-1	23.6 ab	7.0 cde	71.6 abcde
H.bark/A.CMS/Peat/Sand	6-2-1-1	20.5 abc	6.5 cdef	74.9 abcd
H.bark/A.CMS/Peat/Sand	6-1-2-1	14.3 def	5.7 defg	86.2 a
H.bark/H.CMS/Sand	6-3-1	14.3 ef	5.5 defg	59.7 de
H.bark/H.CMS/Peat/Sand	6-2-1-1	15.7 cdef	4.1 fg	62.7 cde
H.bark/H.CMS/Peat/Sand	6-1-2-1	12.7 f	6.4 cdef	67.0 bcde
[1]LSD at .05		4.79	2.76	18.03

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Nitrogen, Phosphorus and Potassium Container Plant Rate Study

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Abstract

Optimum growth as a function of slow-release fertilizer treatments over a two-year period of container-grown Hino Pink azalea, Emerald Gaiety enouymus and Blue Rug juniper occurred at 2.0 lbs actual nitrogen/cu yd., 1.0 lb. P_2O_5 and 1.0—2.0 K_2O depending on species. High rates of nitrogen were phytotoxic and high rates of P_2O_5 and K_2O were non-phytotoxic but were not needed.

Introduction

As fertilizer management becomes more important to producers and the general population alike, it is important to recognize what rates are necessary for optimum crop growth. Applying less than is needed usually produces inferior crops and reduced return to the grower. Applying more than is needed is not only wasted time and money but more importantly can lead to the possibility of increased fertilizer run-off and pollution of soil and water. It is up to fertilizer manufacturers, distributors and salesmen, researchers and Extension personnel to recommend to the producers the minimum amount of fertilizer as well as other agricultural chemicals, that will result in optimum production.

A study was designed to determine what level of nitrogen (N), phosphorus (P), and potassium (K), would result in optimum production of selected woody landscape plants produced in containers. Specifically, N, P_2O_5 and K_2O were evaluated at rates from 0 to 10 pounds in 1-pound increments per cubic yard of media.

Materials and Methods

Since the primary fertilizers used in the nursery industry are slow-release products, eight to nine month coated slow-release sources were selected. The nitrogen source was 39-0-0, the phosphorus was 0-40-0 and potassium 0-0-45. All were calculated to deliver rates from 0 to 10 lbs of actual N, P_2O_5 and K_5O per cu. yd of media.

When nitrogen was varied, the P_2O_5 was kept constant at 1.0 lb./cu.yd and the potash at 1.0 lb./cu.yd. In other words, all nitrogen treatments received a constant level of P and K. When phosphorus was varied, the nitrogen was applied at 2.0 lbs actual and the potassium at 1.0 lb. rate. When potash was varied, all plots received 2.0 lbs N and 1.0 lb. of P_2O_5.

The plants were containerized in April 1988, fertilized 4/20/88 and again 4/17/89. The study was conducted for two growing seasons.

The plants selected for this study were *Rhododendron* 'Hino Pink'— Hino Pink azalea, *Euonymus fortunei* 'Emerald' 'Gaiety'—Emerald Gaiety euonymus and *Juniperus horizontalis* 'Wiltoni'—Blue Rug juniper.

The media was pine bark-peat moss-sand in a 6-3-1 ratio (v:v). The rooted cuttings were potted into one gallon containers and remained in the containers for the two growing seasons.

The study consisted of a randomized block design with three replications of each treatment. There were approximately 200 plants of each species in the study.

Results and Discussion

The quality of each plant was recorded in September, 1989 following two growing seasons. A 1-10 scale was used with 1=dead plants, 7=acceptable and 10=excellent condition. As shown in Table 1, the quality of all three species decreased with higher rates of fertilizer. Azalea quality decreased at rates above 7 lbs., enouymus above 4 lbs., and juniper above 6 lbs.

Table 1. Quality and Dry Weight of Nursery Stock as a Function of Nitrogen Application with P_2O_5 and K_2O constant at 1.0/cu. yd.

Pounds/Cu.yd. Nitrogen	Quality Rating—Visual* Azalea	Euonymus	Juniper
0	3.50 b	2.50 d	3.33 de
1	7.33 a	8.00 ab	8.17 a
2	9.00 a	9.00 a	7.17 ab
3	9.33 a	8.83 a	8.17 a
4	8.17 a	6.83 abc	7.33 ab
5	7.33 a	4.33 d	6.50 abc
6	7.00 a	3.67 c	5.67 abc
7	3.50 b	1.83 d	5.00 bcd
8	2.17 bc	5.17 bd	4.33 cde
9	2.83 bc	1.83 d	3.33 de
10	1.00 c	2.00 d	2.17 e

*Scale 1 to 10 with 10=highest, 7=acceptable and 1=lowest quality
**LSD at 5%

Pounds/Cu. yd. Nitrogen	Dry Weight—Grams Azalea	Euonymus	Juniper
0	12.30 e	5.19 b	12.97 e
1	96.04 ab	50.56 a	59.72 ab
2	118.09 a	48.52 a	66.48 a
3	118.48 a	40.03 a	63.14 ab
4	89.07 b	36.82 a	58.94 ab
5	90.26 b	12.81 b	48.38 b
6	65.34 c	8.75 b	51.20 abc
7	29.53 d	3.91 b	36.84 cd
8	20.85 d	12.43 b	28.26 de
9	27.82 d	1.79 b	16.75 e
10	3.71 e	4.99 b	14.16 e

*LSD at 5%

Vegetative growth expressed as dry weight is also shown for each species in Table 2. Best growth of azalea occurred at rates of 1 to 3 lbs. N/cu. yd, Euonymus at rates of 1 to 4 lbs. and juniper 1 to 6 lbs. This would suggest that azalea and euonymus respond at lower rates than juniper which is more tolerant to higher rates. In actuality, 1 to 2 lbs. of nitrogen per cubic yard produced very satisfactory plants with all three species.

In contrast with nitrogen, the quality of all three species in phosphorus treatments were not affected by treatment rates. As shown in Table 2, the quality was not statistically influenced by rates above 0. The dry weight of azalea was not affected by phosphorus rates between 1 and 10 lbs. The euonymus was inconsistent in response to phosphorus with 10 lbs the best rate. Juniper dry weight was highest at 6 lbs. phosphorus and essentially similar in all other treatments between 1 and 10 lbs. Phosphorus is important in plant growth but plant response to various rates was not observed in rates above 0.

Potassium surprisingly did not result in plant quality differences in any of the plant species as shown in Table 3. The same is true with dry weight of euonymus and juniper. Increasing potassium was inconsistent with azalea with growth in the 0 lbs. potassium the same as the best treatment of 9 lbs. Curling, purpling leaves of azalea were observed in the 10 lb treatment even though growth was no different than the 9 lb rate.

All those fertilizers were slow release formulations thus, phytotoxicity from an excessive salts build up was not evident as would have occurred with uncoated particles in other fertilizers.

Mineral elements levels of azalea foliage as a function of actual N, P_2O_5 and K_2O applied incrementally from 0 to 10 lbs./cu.yd. are shown in Table 4. The results indicate not surprisingly, that with increasing N, P or K the foliage level of that element increases. In all cases, azaleas contained more mineral elements than were needed for optimum growth (2).

Table 2. Quality and Dry Weight of Nursery Stock as a Function of Phosphorus Treatment with N constant at 2.0 lbs and K_2O at 1.0/cu. yd.

Pounds/Cu.yd. Phosphorus	Quality Rating—Visual*		
	Azalea	Euonymus	Juniper
0	4.67 b	3.67 b	3.83 b
1	8.17 a	8.50 a	7.17 a
2	8.17 a	8.17 a	6.33 a
3	8.33 a	7.67 a	7.17 a
4	9.17 a	8.67 a	7.33 a
5	8.83 a	9.33 a	7.00 a
6	7.83 a	8.50 a	7.00 a
7	9.00 a	9.17 a	8.33 a
8	8.83 a	8.33 a	7.67 a
9	8.33 a	8.33 a	7.50 a
10	8.33 a	9.50 a	8.00 a

*Scale 1 to 10 with 10=highest, 7=acceptable and 1=lowest quality
**LSD at 5%

Pounds/Cu. yd. Phosphorus	Dry Weight—Grams		
	Azalea	Euonymus	Juniper
0	28.59 b	5.74 e	20.62 c
1	102.06 a	47.42 bc	60.99 ab
2	97.97 a	42.39 bcd	61.37 ab
3	103.17 a	28.29 d	68.62 ab
4	109.38 a	56.60 ab	53.15 b
5	111.14 a	45.76 bc	50.81 b
6	105.68 a	41.17 cd	73.56 a
7	121.22 a	55.75 ab	65.37 ab
8	113.57 a	38.70 cd	58.20 ab
9	97.12 a	34.83 cd	62.41 ab
10	107.85 a	62.63 a	66.62 ab

*LSD at 5%

Table 3. Quality and Dry Weight of Nursery Stock as a Function of Potassium Treatment with N constant at 2.0 lbs and P_2O_5 at 1.0/cu. yd.

Pounds/Cu.yd. Potassium	Quality Rating—Visual*		
	Azalea	Euonymus	Juniper
0	8.67 a*	7.33 b	7.17 a
1	8.83 a	8.67 ab	8.50 a
2	9.33 a	8.50 ab	7.83 a
3	8.33 a	8.67 ab	8.17 a
4	9.17 a	8.17 ab	8.17 a
5	8.33 a	8.17 ab	8.00 a
6	9.33 a	7.33 b	7.67 a
7	9.00 a	8.17 ab	8.33 a
8	8.33 a	8.67 ab	7.17 a
9	8.83 a	8.50 ab	8.67 a
10	8.67 a	9.17 a	7.67 a

*Scale 1 to 10 with 10=highest, 7=acceptable and 1=lowest quality
** LSD at 5%

Pounds/Cu. yd. Potassium	Dry Weight—Grams		
	Azalea	Euonymus	Juniper
0	119.09 ab	35.98 a	52.63 a
1	89.52 d	38.70 a	69.05 a
2	107.39 abc	40.17 a	62.31 a
3	103.98 bcd	43.27 a	55.11 a
4	106.05 abcd	42.12 a	62.10 a
5	101.00 cd	37.83 a	57.81 a
6	116.09 ab	36.35 a	56.57 a
7	101.61 cd	35.12 a	67.16 a
8	101.10 cd	44.37 a	51.65 a
9	122.59 a	40.54 a	62.33 a
10	105.60 abcd	47.64 a	55.37 a

*LSD at 5%

The media pH and soluble salts as a function of N, P and K applied from 0 to 10 lbs./cu. yd. is shown in Table 5. As the phosphorus level increases, the salts level increases with little appreciable effect on pH. As potassium increases, the soluble salts increases and the pH increases slightly. As nitrogen increases, soluble salts did not change until high rates of 8 and 10 pounds were reached and then the salts level decreased. It is surprising that the salts decreased, but may be due to increased leaching over time as more water entered those pots with fewer and smaller plants due to injury caused early in the first year of the study. The pH did not change in nitrogen treatments between 2 and 10 lb. treatments.

Table 4. Mineral Element Levels of Azalea Foliage as a Function of Actual N, P_2O_5 and K_2O Applied Incrementally from 0 to 10 Pounds/ cu. yd.

lbs./cu.yd Nitrogen	Total Foliar N-%	lbs./cu.yd Phosphorus	Total Foliar P-%	lbs./cu.yd Potassium	Total Foliar K-%
0	1.14 h*	0	.05 h	0	.27 e
1	1.37 g	1	.13 gh	1	.43 d
2	1.48 g	2	.18 fg	2	.48 d
3	1.50 fg	3	.24 ef	3	.53 cd
4	1.73 de	4	.33 de	4	.54 cd
5	1.67 ef	5	.38 cd	5	.62 bc
6	1.90 cd	6	.46 bc	6	.69 ab
7	2.03 bc	7	.47 bc	7	.61 bc
8	2.30 a	8	.52 b	8	.63abc
9	2.15 ab	9	.63 a	9	.70 ab
10	——	10	.70 a	10	.74 a

*LSD at 5%

Summary

The three plants in this study, Hino Pink azalea, Emerald Gaiety euonymus and Blue Rug juniper showed considerable tolerance to high rates of slow release nitrogen, phosphorus and potassium. The best growth of all three species occurred at 2.0 lbs actual nitrogen, 1.0 lb. actual P_2O_5 and 1.0 or 2.0 lb. K_2O depending on species.

High rates of nitrogen were damaging to the plants at different rates depending on species while high rates of phosphorus and potassium were not beneficial or damaging thus not needed.

Producers should conduct similar studies at lower rates with their fertilizers to determine optimum growth and to determine if they can reduce the rate or number of applications to work toward protecting the environment and saving money.

Table 5. Media pH and Soluble Salts as a Function of Actual N, P_2O5 and K_2O Applied Incrementally from 0 to 10 lbs/cu. yd.

Lbs/ cu.yd N	pH	SS	Lbs/ cu.yd P_2O_5	pH	SS	Lbs/ cu.yd K_2O	pH	SS
0	4.73a[1]	.21cde	0	4.12abc	.23de	0	3.55c	.20g
1	5.10b	.26bcd	1	4.18abc	.22e	1	4.17b	.32fg
2	4.05b	.26bcd	2	4.4a	.20e	2	4.53a	.23gfe
3	3.98b	.40a	3	4.08abc	.27cde	3	4.75a	.23efg
4	3.75b	.33ab	4	4.07abc	.30bcde	4	4.47a	.54cde
5	3.98b	.23bcde	5	4.23abc	.35abc	5	4.75a	.53def
6	4.00b	.23bcd	6	4.05abc	.30bcde	6	4.83a	.40de
7	3.75b	.26bcd	7	4.00bc	.35abcde	7	4.73a	.75abc
8	3.77b	.13e	8	3.83c	.40ab	8	4.88a	.84bcd
9	3.80b	.27bc	9	4.28abc	.33bcd	9	4.97a	.67a
10	4.07b	.15de	10	3.93bc	.45a	10	4.93a	.60ab

[1]LSD at 5%

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Characteristics of English Roses During Their First Year of Establishment

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Abstract

Ten cultivars of English roses were planted for evaluation in a display garden in Wooster, Ohio. The plants became well established and had completed two flushes of flowers by mid-August. Flowers were abundant and provided a unique combination of characteristics between old garden roses and modern roses.

Introduction

A new class of roses, called English roses, has become available on the market as a result of over 35 years of breeding work by David Austin of Albrighton, England. This diverse group of roses combines the characteristics of old garden roses with those of modern roses like hybrid-teas, floribundas and modern climbers. The result is a plant that has the charm, form and fragrance of an old garden rose and also the attribute of repeat-flowering. The breeding program has also produced new combinations of fragrance, color and leaf characteristics (1).

Ten cultivars of English roses were planted in the horticultural display gardens on the campus of The Ohio State University Agricultural Technical Institute in the spring of 1990. The growth, development and flowering characteristics of these plants were observed during their first growing season.

Materials and Methods

The 10 English rose cultivars listed in Table 1 were selected for study. Three plants per rose cultivar were planted in 3′ wide beds in early April 1990. The plants had been received dormant and bare root from a commercial nursery. The growing beds were prepared for planting by removing sod, adding organic matter and tilling the soil thoroughly and deeply. Plants were set 4′ apart in accord with the landscape plan being followed. At least two sides of every bush were to the outside of a curved bed. The plants were mulched 2″ deep with decomposed bark. Standard cultural practices for fertilizing and insect/disease control were followed (3).

The first flush of bloom occurred in mid- to late-June. A second flush occurred in early August. Results reported are for the second round of flowering in August. Average plant size and the number of canes per plant are recorded in Table 1. Flowering characteristics are reported in Table 2. This information includes overall floriferousness and individual flower characteristics. Specifics include number of canes showing color, diameter of flowering spray, number of flowers/spray, diameter of individual open flowers and color of the flower.

Results and Discussion

Ten cultivars of English roses grew and flowered well in the ATI horticultural display gardens during the 1990 growing season. By early August all cultivars were in their second flush of bloom. The bloom was significant and created considerable interest in the landscaped garden. This repeat blooming characteristic is one of the important attributes of this new class of roses.

The growth of the plants was significant enough by August to form bushes with a shrub-like habit. Canes began arching outward resulting in a form reminiscent of old garden roses. Sizes of the plants varied by cultivar as did leaf characteristics (Table 1). Variations in plant form and foliage is understandably different since very diverse parentage has been combined to produce this class of roses (1).

Table 1. Plant Size and Number of Canes/Plant for English Roses 3 Months After Planting.

Cultivar	No. of Major Canes (Over 60 CM)	No. of Minor Canes (Under 60 CM)	Avg. Height of Major Canes (CM)	Avg. Plant Spread (CM)
Abraham Darby	15.3	1.3	76.3	63.7
English Elegance	7.7	6.0	39.7	43.7
English Garden	7.0	2.3	49.3	38.3
Fair Bianca	9.7	4.7	45.0	34.0
Gertrude Jekyll	14.3	2.0	66.0	58.3
Graham Thomas	12.3	2.0	67.3	49.0
Heritage	5.3	5.0	51.0	48.7
Mary Rose	14.3	2.7	62.3	57.3
Othello	7.0	2.3	58.7	45.0
The Squire	7.0	2.3	50.3	52.0

Table 2. Flowering Characteristics of English Roses During the Second Flush of Bloom—Early August.

	Avg. No. of Canes Showing Color/Plant	Avg. Diameter of Flowering Spray (CM)	No. of Flower Buds/Spray	Avg. Diameter of Open Flower (CM)	Color of Flower
Abraham Darby	6.3	—	1.0	8.2	Apricot Yellow
English Elegance	9.3	12.7	1.6	7.8	Light Salmon-Pink with Gold Blush
English Garden	5.3	17.5	2.3	8.5	Buff Yellow
Fair Bianca	12.7	15.3	2.5	6.8	White
Gertrude Jekyll	2.7	5.0	1.7	7.3	Pink
Graham Thomas	5.0	—	—	8.0	Yellow
Heritage	5.0	16.0	1.1	8.5	Soft Pink
Mary Rose	6.7	14.3	2.2	7.3	Rose Pink
Othello	2.0	16.0	1.5	9.5	Dark Crimson
The Squire	3.7	17.7	2.8	9.2	Dark Crimson

Flowers were double, cupped and rosette shaped. Many were very full-petaled and fragrant. Colors included variations of pink, white, yellow and red. The color range is wider than in a typical collection of old garden roses. The apricot, peach and buff tones were especially unique. "English Elegance" represents the unusual beauty and complexity of color in English roses. This cultivar had blush colored outer petals which blended into pink and eventually salmon toward the center of the flower. The back of the petals had gold tones superimposed over the other colors. As the flowers unfolded, they provided an ever changing panorama of subtle color changes.

English roses are likely to become very popular among gardeners because they offer a unique and appealing combination of old garden rose characteristics with the desired ability to flower more than once a year. The charming flowers provide new and appealing color combinations with classic old rose fragrance. The vigorous growth of the plants and the abundant production of beautiful flowers during the 1990 growing season in Wooster, Ohio will make them candidates for future study.

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Evaluation of Hip Development on Old Garden Roses

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Abstract

Old garden roses that produced conspicuous fruit during the 1990 growing season were observed. The quantity of fruit and individual hip characteristics were recorded as an indicator of their landscape value in late summer and early autumn.

Introduction

One of the desirable attributes of old garden roses is the development of colorful fruit in the late summer and autumn months. These fleshy structures, called hips, vary in size, shape and color. Some bushes produce a profusion of hips which persist into the winter and have of considerable decorative interest.

Twenty-four cultivars and species of roses in The Garden of Legend and Romance, on the campus of the Ohio Agricultural Research and Development Center in Wooster, were studied relative to their hip development during the 1990 growing season. Since old garden roses are becoming increasingly available from commercial nurseries, it is worth noting the late season contribution that these plants can make to the garden.

Materials and Methods

From July 1 to September 21, 1990, 24 species and cultivars of roses growing in the OARDC rose garden were observed bi-weekly for evidence of fruiting hips. Three plants of a species or cultivar are arranged in triangular groupings with 3′ to 5′ centers. The plants are grown in mulched landscaped beds and are given standard cultural practices. There is no special winter protection.

Some pruning and cut-back occurs in late summer to shape the plants, control height and keep bushes within the bounds of the designated beds. Therefore, some potential hip development is eliminated by this summer pruning.

Observations included the shape of the hips, diameter of the individual hips, color of the hips, number of hip clusters per plant and the number of hips per cluster. Most results are reported based on mid-September observations.

Results and Discussion

Results of mid-September observations of the 24 species and cultivars of fruiting old garden roses are listed in Table 1. The roses are grouped into recognized categories based on their heritage. Composite results give an indication of the abundance and showiness of late season hip development.

The largest and most conspicuous hips were found among the rugosa shrubs and their hybrids. The fruit averaged 2.5 cm in diameter with 3-5 hips per cluster being quite common. Since most of the rugosa roses continue to produce some flowers throughout the growing season, many plants bore fruit in various degrees of coloration, ranging from green through orange to dark red. These clusters were set amid dense, rugged foliage with a few flower buds and open flowers. White flowers with colorful fruit against a dark green background was particularly striking on the cultivar 'Schneezwerg' and *Rosa rugosa alba.*

Smaller but very prolific fruit was found on various species roses. Because of the severe die-back resulting from the extremely cold December temperatures during the 1989-90 winter, the number and length of mature canes with fruiting potential was less than that observed during many other years.

Rosa moyesii and *Rosa sweginzowii* were distinctive because of the small orangish-red oval-shaped fruits. *Rosa humilis* had small clusters of bright red shiny fruit that was round in shape. Another variation was the sparse glandular hairs over the surface of the hip on *Rosa waitziana macrantha.*

The two cultivars of shrub roses that were observed had greenish fruit with a slight orange blush in mid-September. Although not showy from a distance, they provided interesting detail at close range. The large pink semi-double flowers of 'Ilse Haberland' and the sparse single yellow flowers of 'Golden Wings' resulted in a fascinating tapestry of flowers, fruit and foliage.

Rose hips extend the enjoyment of old garden roses in the landscape. Their development and subsequent coloration provides a dynamic process which gardeners can anticipate. The showy fruit is visually pleasing when combined with the colors of autumn flowers and foliage. Since hips persist into the winter, they extend the time that the plant has significant aesthetic qualities.

Rose hips are prized for their flavor, being used to produce syrups, jams and teas (3). Their high vitamin C content is widely known. Other medicinal uses have been reported and are still under investigation (1,3). If left on the bush, some hips are eventually consumed by birds or other wildlife. These are additional reasons for noting the hip development on old garden roses.

Table 1. Hip Characteristics and Quantity of Fruit Development of Old Garden Roses—1990.

	Shape	Diameter of individual hips (cm)	September color	No. of hip clusters/ plant	No of hips/ cluster
SPECIES ROSES					
Rosa humilis	round	1.5	bright red	7.3	5.0
Rosa laxa ('Retzius')	round	1.0	orange	75.3	7.7
Rosa moyesii	oval	1.5	orangish red	6.7	5.3
Rosa nitida	round	1.5	green with orange blush	86.7	6.0
Rosa rubrifolia	round	1.5	red	17.3	5.3
Rosa sweginzowii	oval	1.5	red	7.7	5.0
Rosa waitziana macrantha	round	1.5	orange	6.3	5.0
Rosa watsoniana	round	1.5	orange	6.7	4.7
SEMI-CLIMBING MUSK ROSES					
'Erfurt'	round	2.0	green (gold blush)	13.0	8.7
'Nymphenburg'	round	2.5	green	18.0	14.0
'Sangerhausen'	round	2.0	green	20.5	10.5
EGLANTERIA					
Rosa eglanteria	round	1.5	orangish red	37.0	7.3
RUGOSA SHRUBS AND THEIR HYBRIDS					
'Frau Dagmar Hartopp'	round	2.5	reddish orange	17.3	2.0
'Hansa'	round	2.5	red	15.2	3.3
Rosa rugosa	round	3.0	dark red	24.7	4.0
Rosa rugosa alba	round	2.5	orange red	19.7	6.3
Rosa rugosa rubra	round	2.5	green, orange, red	32.0	4.7
'Schneezwerg'	round	1.5	red, orange, green	7.0	1.5
'Therese Bauer'	round	2.5	dark red	9.3	3.7
'Thusnelda'	oval	2.5	red	17.0	5.7
'Therese Bugnet'	oval	2.5	red	10.3	4.2
SHRUB ROSES					
'Golden Wings'	round	1.5	green	30.0	4.7
'Ilse Haberland'	round	1.5	green with orange blush	11.7	2.0
'Scharlachglut'	oval	2.5	red	47.3	3.0

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Light Transmission Characteristics of Some Polyethylene Film Greenhouse Coverings

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Abstract

Daily cumulative transmission of Photosynthetic Photon Flux (PPF) was monitored for seven polyethylene greenhouse coverings, including C-I-L 2 and 3 (CIL, Inc.), Monsanto 602 and 603 (Monsanto Corp.), PolyDress (FVG America, Inc.), Tufflite 3 (Armin Plastics), and VisQueen 1504 (Ethyl/Visqueen Corp). Daily cumulative PPF transmission through double layer (3.8 cm spacing) 6 mil film was monitored from March 16 to April 16, 1984. Percent of ambient cumulative PPF transmitted through film ranged from 77.6 percent for Tufflite 3 to 70.5 percent for C-I-L 2. Cumulative PPF transmission of C-I-L 3 (74.8 percent) ranked second, Monsanto 602 (72.8 percent) and 603 (72.4 percent) ranked third and C-I-L 2 ranked (70.5 percent) fourth. Variation of daily cumulative PPF transmission within rolls of film was significant only for Tufflite 3 (2.3 percent) and CIL 2 (2.7 percent). Spectral transmission from 300 to 850 nm and 2500 to 18000 nm was measured for C-I-L 2 and 3, Monsanto 602, 603, 703, and Cloud Nine, PolyDress, Tufflite 3 and VisQueen 1504. All films displayed similar spectral transmission for 300-850 nm except Tufflite 3, Monsanto 703 and Cloud Nine. Transmitted infrared radiation (2500-18000 nm) was similar for all polyethylene films except Monsanto Cloud Nine which transmitted less radiation in the 7000 to 18000 nm range.

Introduction

In the northern United States and Canada, ambient light levels are often too low to achieve maximum greenhouse crop production during winter months. Maximizing light reception to crops inside a greenhouse is a high priority. Light penetration will depend, to some extent, on the material covering the greenhouse.

The use of polyethylene film as a covering for greenhouses has become commonplace since its introduction into the greenhouse industry about 30 years ago. There has been a considerable increase in the types and sources of polyethylene films that are available (1). Through visual observation, it may appear that various brands of polyethylene films have an influence on the amount of ambient radiation entering the greenhouse environment (1). Unfortunately, much of the research regarding the transmission of radiation through greenhouse coverings has focused on comparing different types of coverings, rather than examining similar materials (5, 6, 7, 9, 10). Research conducted by Sherry and White (9, 10) suggest that there are significant differences in the transmission of the photosynthetically active radiation (PAR) spectral region among polyethylene films and that these differences may be responsible for differences in the productivity of cut roses and geranium stock plants.

Studies were undertaken to examine the "light" transmission characteristics of ten different polyethylene film greenhouse coverings that are currently available to greenhouse growers. This work focused on transmission of daily cumulative photosynthetic photon flux (PPF) through polyethylene films, since PPF is an accepted characterization of "light" to which plants respond.

The objectives of this research were to: 1) monitor daily cumulative photosynthetic photon flux (PPF) through commercially available 6 mil polyethylene films; 2) assess the variability in transmission of PPF among samples taken from a commercial size role of each film; 3) determine the impact of weathering on transmission of daily cumulative PPF through polyethylene films; and 4) measure the spectral transmittance of these films throughout the 300-850 nm and 2500-18000 nm wavebands.

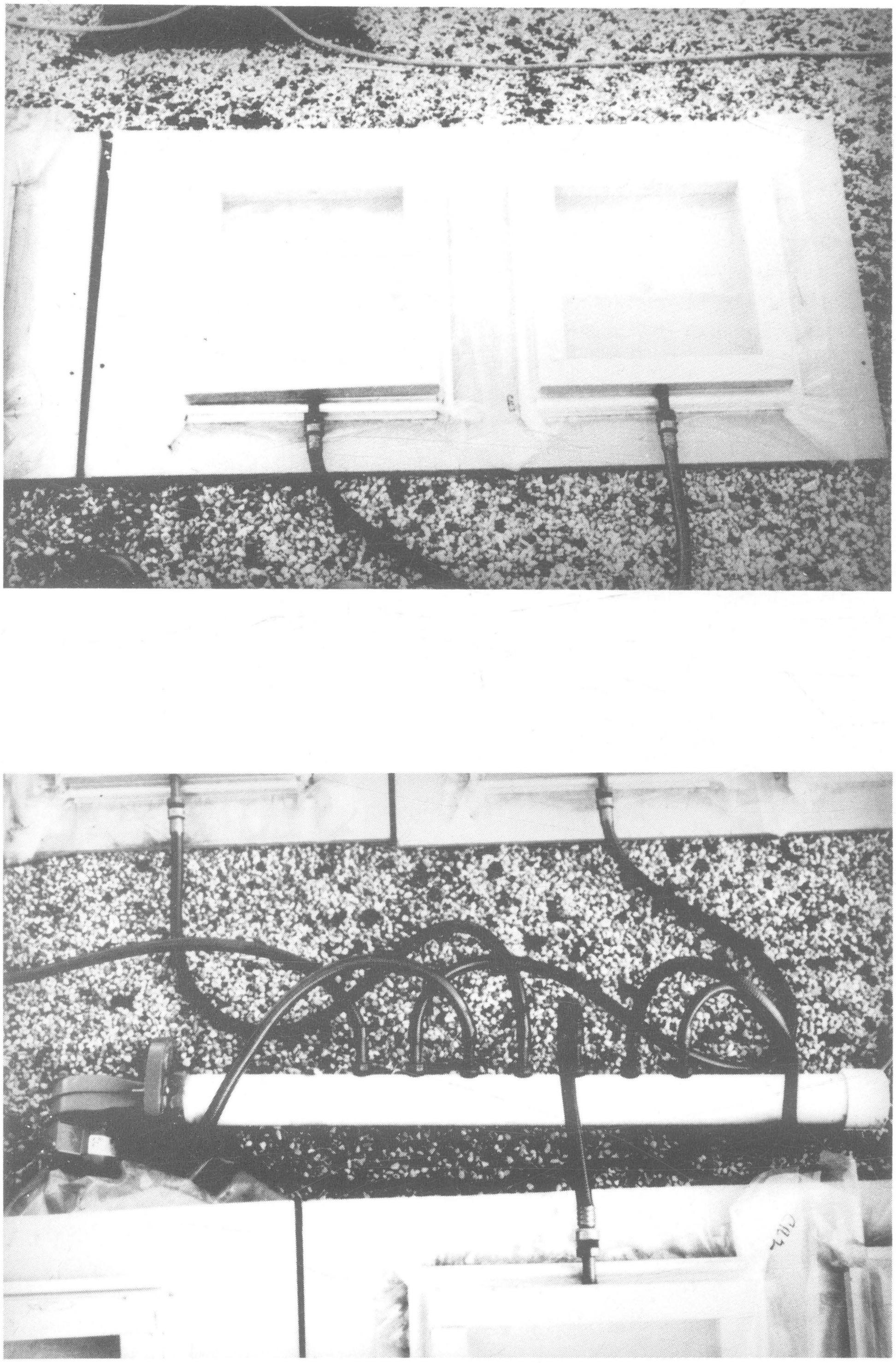
Materials and Methods

An apparatus was constructed for measuring daily cumulative PPF through different polyethylene films under outdoor conditions. This apparatus was designed so that two layers of polyethylene film could be mounted 3.8 cm apart on a square wooden frame having an area of .093m^2 (Figure 1). A LI-COR model LI-185 SB quantum sensor (LI-COR, Inc., Lincoln, Nebraska) was mounted under each double layer of film on plywood frames (Figure 1). A neutral gray color cheesecloth was applied to the frame to allow for air exchange. A squirrel cage fan was utilized to minimize heat accumulation and condensation between the two layers of film (Figure 1). The frames were set at a 27 degree angle (to level), and oriented due south.

Cumulative PPF was recorded daily from 0800 to 1700 hours EST for each polyethylene film tested, plus a control (no polyethylene film), using a LI-COR model LI-1776 integrator. Each sensor/integrator combination was calibrated relative to a certified sensor acquired from LI-COR, Inc. Calibration was performed by placing all sensors in ambient light conditions and integrating daily PPF for a period of five days. Calibration factors were used to compensate for differences in integration among the sensor/integrator combinations. Daily percent transmission was calculated for all outdoor trials by dividing transmitted radiation by ambient radiation (uncovered, frame, control).

In laboratory studies, spectral transmittance in the 300-850 nm range was measured with a spectrophotometer assembled from component equipment. A quartz prism Perkin-Elmer model 83 monochromator (Perkin-Elmer, Norwalk, Connecticut) was used for radiation wavelength selection from an Oriel model 6144 tungsten-halogen light source (Oriel Corp.,

Figure 1. Close-up view (a) and position of blower used to inflate between the layers with outside air (b) of a light collection apparatus used to mount polyethylene films.



Stratford, Connecticut) for the 450-850 nm range. For the 300-450 nm range, a PRA model ALH-220 Xenon arc lamp (Photochemical Res. Assoc., Oak Ridge, TN) was employed. The slitwidth was adjusted so that the spectral bandwidth was 10nm throughout the wavelength ranges monitored. Radiation was modulated using an EG&G model 192 light chopper (EG&G Inc., Salem, MA) at a frequency of 500 Hz. Modulated mono-chromatic radiation was focused on a polyethylene sample placed against the entry port of an integrating sphere. This integrating sphere was utilized so that all radiation, including radiation scattered by the sample, could be detected. Experimental techniques followed recommendations published by the American Society of Testing and Materials (2,3,4). An EG&G HUV-100 B UV-enhanced silicon photodiode was used to detect radiation collected by the integrating sphere. The detector was mounted through a port at a 90 degree angle to the light entry port of the sphere. An EG&G model 5205 lock-in amplifier was used to measure the voltage response from the detector. Percent transmission was calculated by dividing the detector voltage response from transmitted radiation by the non-transmitted radiation (control). Percent transmission within three wavelength ranges (300-400, 400-700, 700-850 nm) were calculated by integrating each of these regions under the spectral transmission curves. Sections of spectral transmission curves were cut out, plotted on graph paper and the area measured using a LI-COR model LI-3000/LI-3050A area meter. The area under each curve was divided by the total area of the graph to obtain the transmission values for each wavelength range.

Spectral transmittance was measured in the thermal infrared range (2500-18000 nm) using a Pye Unicam model 3-200 scanning infrared spectrophotometer (Sargent-Welch Sci. Co., Skokie, IL).

Experiment 1

Seven polyethylene films were examined for transmission of daily cumulative PPF. Both two and three year rated films were evaluated, including: C-I-L 2 and 3 (CIL Plastics), Monsanto 602 and 603 (Monsanto Corporation), VisQueen 1504 (Ethyl/Visqueen Corporation), PolyDress (FVG America, Inc.), and Tufflite 3 (Armin Plastics). PPF was monitored when these plastics were initially set outdoors from March 16, 1984 to April 16, 1984 and monitored again a year later from May 6, 1985 to May 17, 1985.

A factorial design was used to analyze the experimental data. Polyethylene and light conditions were the main effects for new and weathered polyethylenes. The light conditions were classified as either sunny or cloudy days. Sunny days were characterized as days where light conditions were greater than 350 μmol s^{-1} m^{-2} PPF (instantaneous measurements) for at least half of the day and cloudy days as those days with less than 350 μmol s^{-1} m^{-2} PPF for more than half of the day. Each day of integration was considered a replication for all polyethylenes. A minimum of ten total replications for both the new polyethylene and the weathered polyethylene portion of the experiment were recorded.

Experiment 2

This experiment examined the variation of transmitted daily cumulative PPF within each roll of polyethylene. The time frame for this study was from June 1984 to December 1984. Polyethylenes used in this experiment included C-I-L 2 and 3, Monsanto 602, 603, 703 and Cloud Nine, VisQueen 1704 (experimental), PolyDress and Tufflite 3.

Three samples were randomly selected from each roll of film and mounted on the light monitoring apparatus. Daily Cumulative PPF was considered a replication with ten replications for each sample of polyethylene film. Analysis of variance was used to compare samples from each roll of polyethylene film examined and means separated using Duncan's multiple range test.

Experiment 3

This experiment was conducted to monitor daily cumulative PPF through seven different "three year rated" polyethylene films. Polyethylene films used included C-I-L 3, Monsanto 603, 703 and Cloud Nine, VisQueen 1704, PolyDress, and Tufflite 3. Effects of environmental dust deposition upon the surface of these films on daily PPF was also examined. This experiment was conducted from April 9, 1985 to May 4, 1985.

Before daily PPF was monitored, the polyethylene films were placed outdoors and permitted to accumulate a residue of ambient particulate matter which typically occurs on polyethylene greenhouse coverings. One month after setting the seven film samples outdoors, daily cumulative PPF was monitored for ten days with each day considered a replication. Thereafter, the residue on each film was gently washed off all samples every other day using distilled water and daily PPF was monitored for an additional ten days.

This experiment was analyzed as a 7×2 factorial with 10 replications using a two way analysis of variance. Duncan's multiple range test was used to separate the means.

Experiment 4

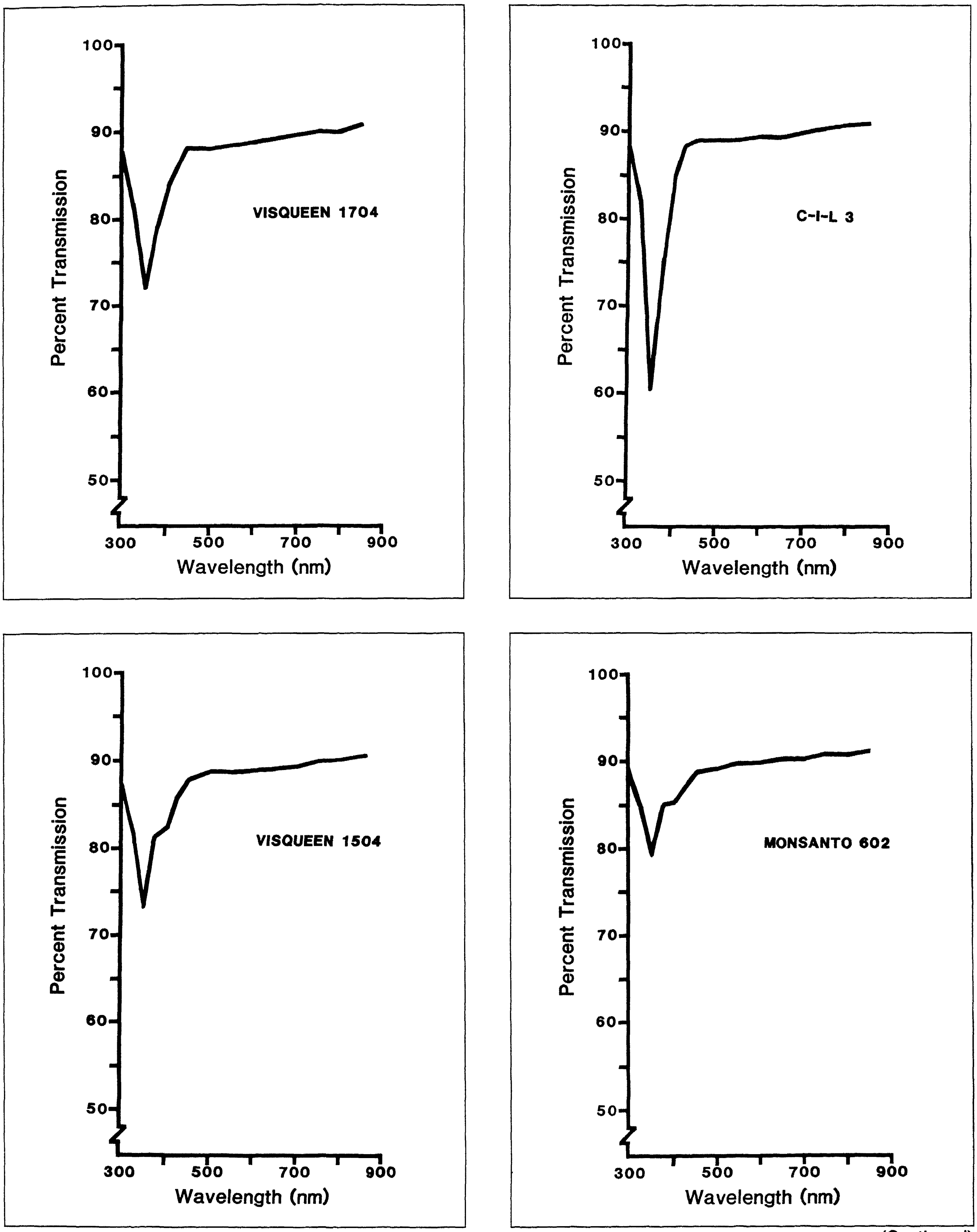
This experiment was designed to monitor spectral transmission of polyethylene films, from 300-850 nm, including low ultraviolet, visible, and high infrared portions of the spectrum. Spectral transmission from 2500-18000 nm (thermal infrared) was also monitored. Three samples of all polyethylene films were randomly selected from a roll of film, mounted in photographic slide frames and monitored using spectrophotometers.

Spectral transmission curves shown in Figure 2 have been developed using the mean for transmission of three replications. The variation among replications were extremely low for all wavelengths.

Integrated portions of the spectrum were statistically analyzed as a completely randomized design. Duncan's multiple range test was used to separate the means for all polyethylenes tested for the three wavebands integrated.

Spectral transmission curves presented in Figure 3 for the 2500-28000 nm range are representative spectrographs for the three replications. In these trials, variation among replications was also negligible.

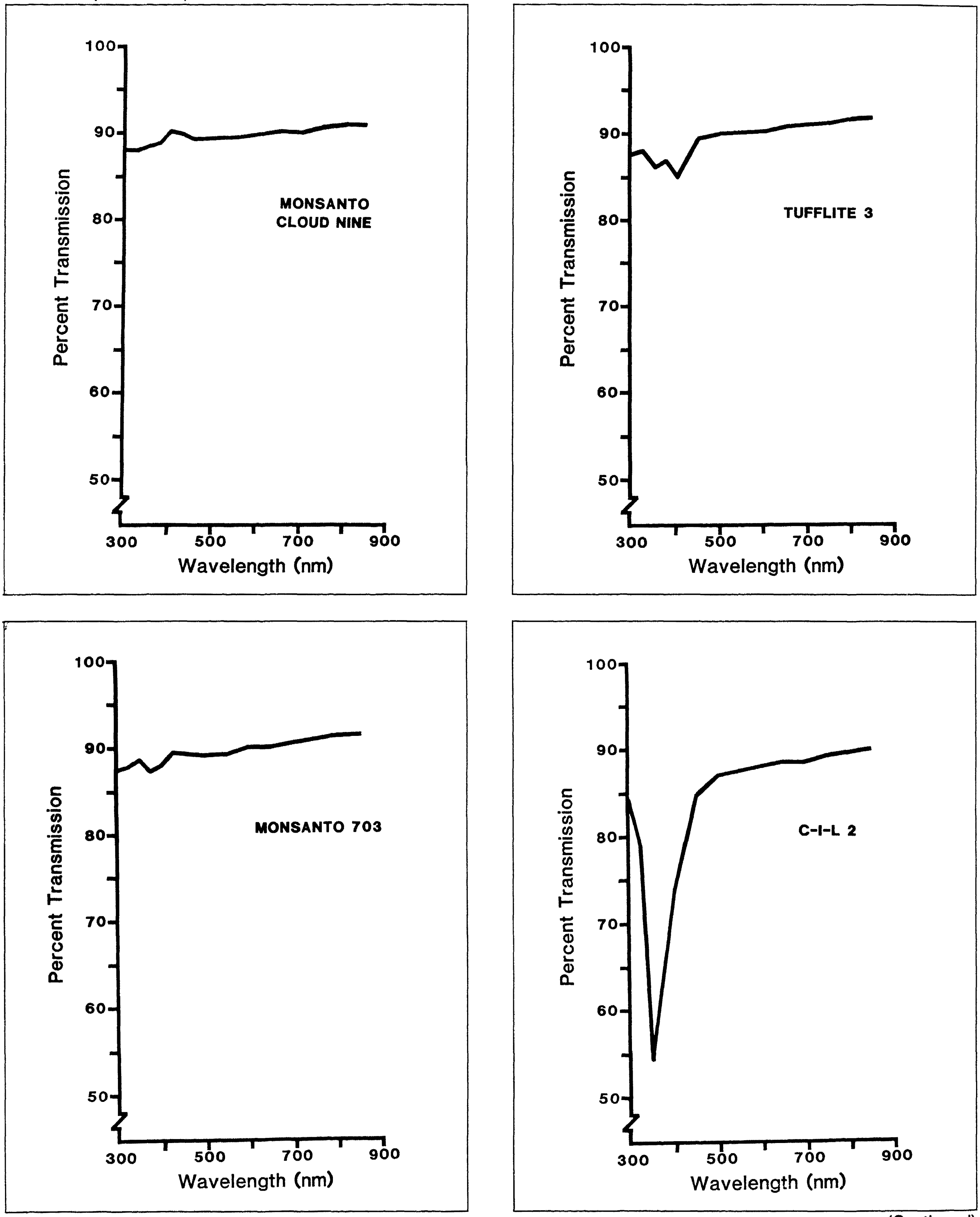
Figure 2. Spectral transmission of radiation from 300-850 nm through several greenhouse polyethylene films[1].



(Continued)

[1]Methods for quantifying transmission followed testing standards recommended by the American Society for Testing and Materials (3, 4), and includes the use of a spectrophotometer equipped with an integrating sphere.

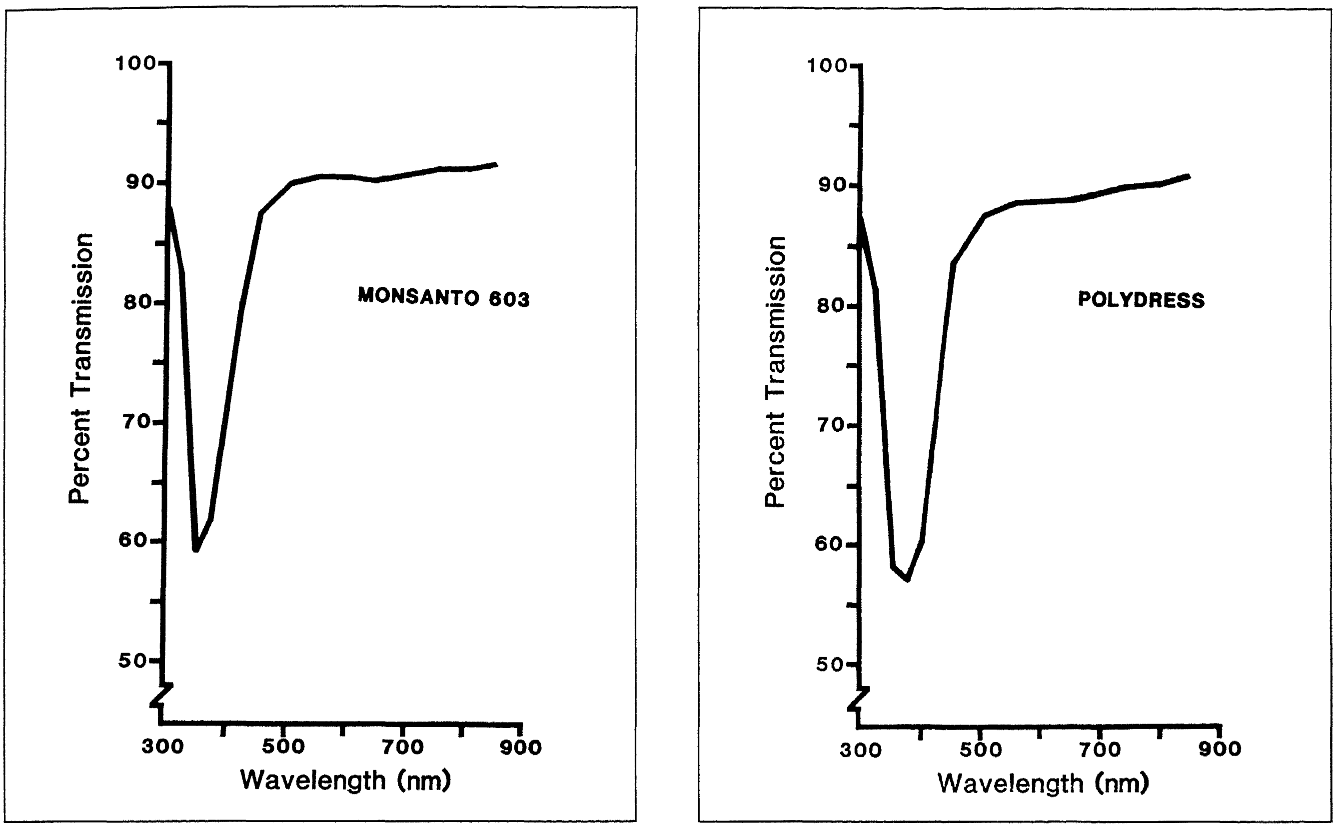
Figure 2. Spectral transmission of radiation from 300-850 nm through several greenhouse polyethylene films[1]. (Continued)



(Continued)

[1]Methods for quantifying transmission followed testing standards recommended by the American Society for Testing and Materials (3, 4), and includes the use of a spectrophotometer equipped with an integrating sphere.

Figure 2. Spectral transmission of radiation from 300-850 nm through several greenhouse polyethylene films[1]. (Continued)



[1]Methods for quantifying transmission followed testing standards recommended by the American Society for Testing and Materials (3, 4), and includes the use of a spectrophotometer equipped with an integrating sphere.

Results

In the outdoor trials, Tufflite 3, C-I-L 3, Monsanto 703 transmitted the most daily cumulative PPF of all polyethylene film greenhouse coverings tested, with Tufflite 3 transmitting the greatest amount of daily cumulative PPF (Tables 1,3). There were no differences in daily cumulative PPF between sunny or cloudy conditions (data not shown). Tufflite 3 and C-I-L 2 were shown to have the greatest amount of variability in transmittance of PPF within a roll of polyethylene film. Tufflite had a range of 2.3 percent variability and CIL-2 had a range of 2.7 variability (Table 2). Tufflite 3 transmitted the greatest amount of daily cumulative PPF after being subjected to outdoor conditions for one year, whereas C-I-L 2 ranked second in transmission of PPF. On the average, there was a 6.6 percent decrease in transmission of daily cumulative PPF for all polyethylene films after one year (Table 1). The residue of dust and particulate matter which accumulated on polyethylene films significantly reduced light transmission on an average of 3.2 percent (Table 3). Monsanto Cloud Nine had shown the greatest reduction at 6.1 percent and Monsanto 603 was reduced the least at 1.6 percent. There was no significant difference in percent transmission when comparing sunny verses cloudy days (Table 1).

In the laboratory study, Monsanto Cloud Nine, Tufflite 3, and Monsanto 703 demonstrated the greatest transmission of total radiation (300 to 850 nm); whereas, PolyDress demonstrated the least.

Spectral transmission was similar for all polyethylenes except Monsanto 703 and Cloud Nine, and Tufflite 3. These three films did not appear to have a considerable decrease in transmission below 500 nm, as did the other polyethylene films (Figure 2). All polyethylenes displayed similar transmission characteristics in the 2500-18000 nm range except for Monsanto Cloud Nine (Figure 3). Monsanto Cloud Nine demonstrated a considerable decrease in transmission within the 2500 to 3625 nm range and 7000-18000 nm range as compared to the rest of the films.

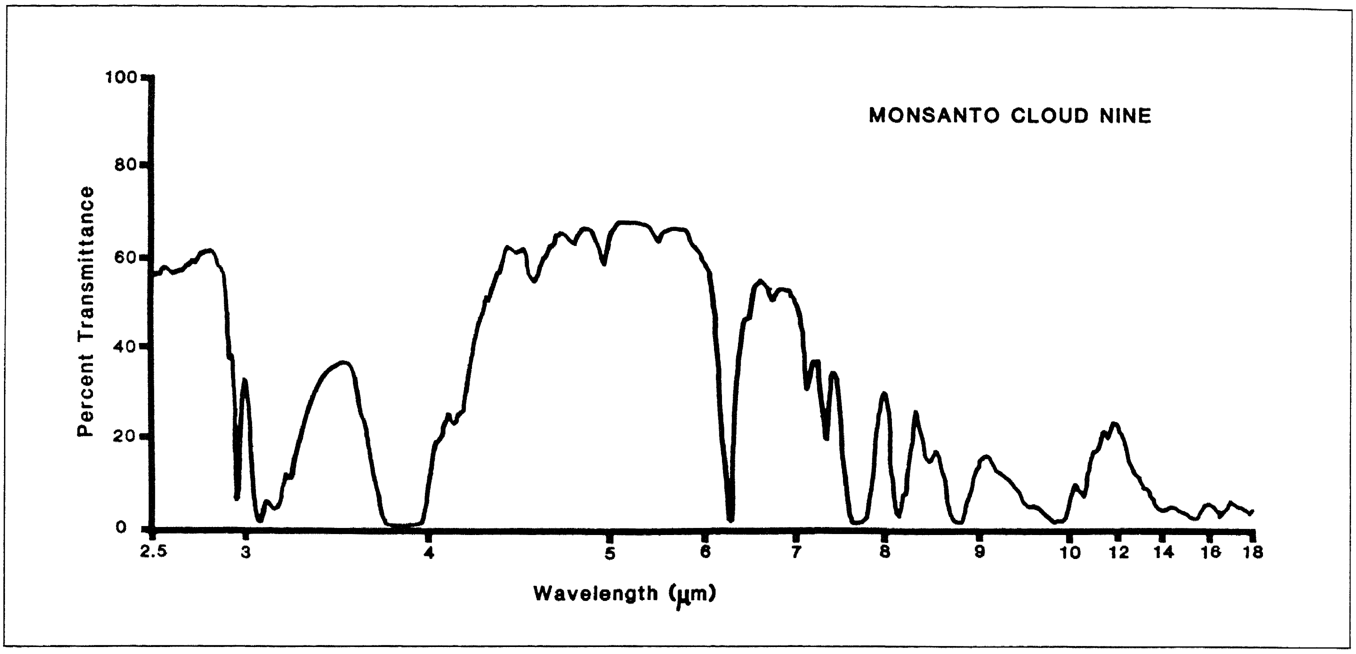
Discussion

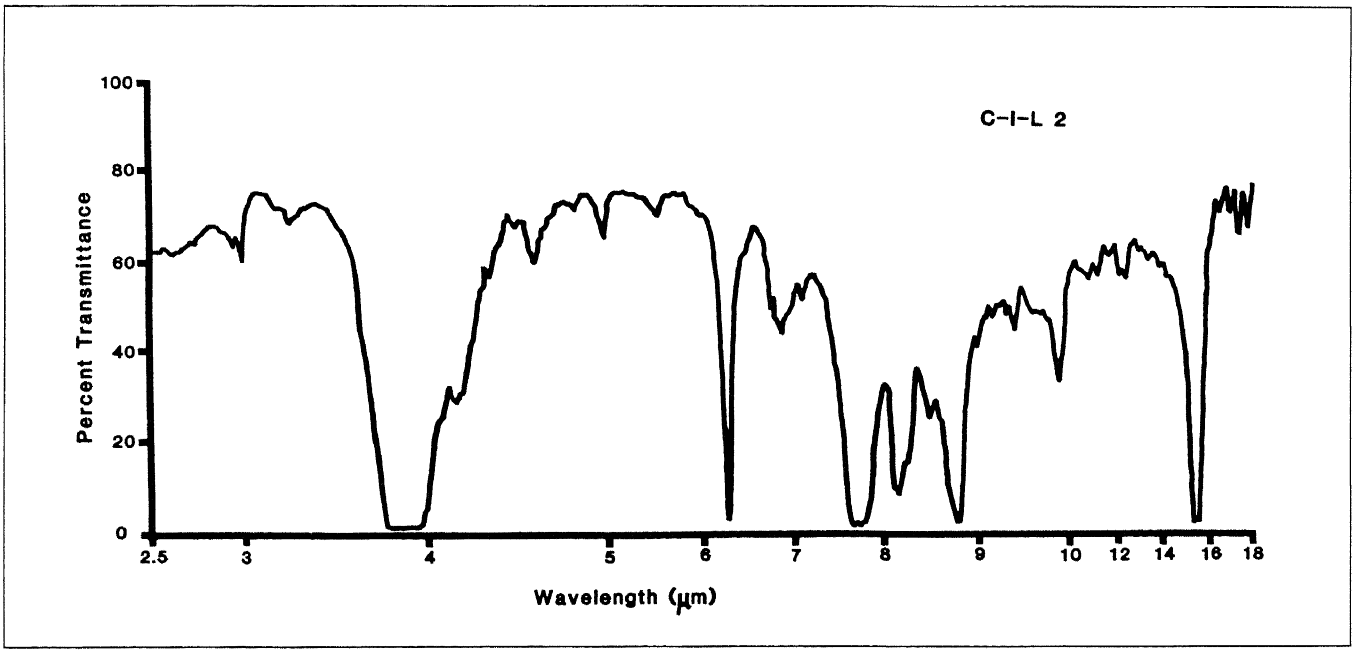
Among all polyethylene film greenhouse coverings tested, Tufflite 3 transmitted the greatest amount of daily cumulative PPF under outdoor conditions. C-I-L 2 and Monsanto 703 transmitted more PPF than the remainder of the polyethylenes examined.

Significant differences were found within rolls for Tufflite 3 and C-I-L 2. Reasons why these two films had significant variation are not understood. However, it is believed that this variation within rolls did not significantly affect the ranking among polyethylene films studied.

For the weathered polyethylene films, it is interesting to note that C-I-L 2 did not display a reduction in transmission

Figure 3. Spectral transmission of radiation from 2500-18000 nm through Monsanto Cloud Nine and C-I-L 2 greenhouse polyethylene films[1,2].





[1]Transmission of radiation within this waveband was measured using a Pye model 3-200 scanning infrared spectrophotometer.
[2]C-I-L 2 represents the spectral transmission typical of all polyethylene films tested except for Monsanto Cloud Nine.

Table 1. Mean Percent Transmission of Daily Cumulative PPF Through Various Greenhouse Polyethylene Films Immediately (Initial) and One Year After Placement Outdoors (Year Later)[1].

Polyethylene Film	Mean Percent (%) Transmission	
	Initial[2]	Year Later
Tufflite 3	77.6a	71.6a
C-I-L 3	74.8b	67.6c
Monsanto 602	72.8c	64.6d
Monsanto 603	72.4c	67.2c
PolyDress	71.1d	65.5d
VisQueen 1504	70.6d	58.2e
C-I-L 2	70.5d	69.0b

[1]Data Collected 3-16-84 to 4-16-84 between 8 a.m. and 5 p.m. each day; both sunny (>350 PPF) and cloudy (<350 PPF) days included in data analysis.
[2]Mean separation within columns using Duncans multiple range test at the 0.05 level of significance.

Table 2. Mean Percent Transmission of Daily Cumulative PPF of Samples Taken Within Each Roll of Various Polyethylene Films.

Polyethylene	Sample			
	1	2	3	Range
C-I-L 2	70.8a[1]	70.4a	68.1b	2.7
C-I-L 3	74.4a	73.3a	73.0a	1.4
Monsanto 602	74.4a	74.3a	74.2a	0.2
Monsanto 603	75.0a	75.0a	74.9a	0.1
Monsanto 703	77.5a	77.3a	76.6a	0.9
Monsanto Cloud Nine	70.5a	70.1a	69.2a	1.3
VisQueen 1704	77.2a	77.0a	76.2a	1.0
PolyDress	77.1a	76.2a	75.3a	1.8
Tufflite 3	80.0a	78.9ab	77.7b	2.3

[1]Mean separation within rows using Duncans multiple range test at the 0.05 level of significance.

Table 3. Mean Percent Transmission of PPF Through Greenhouse Polyethylene Films, With (Residue) and Without (No Residue) Surface Dust Accumulation.

Polyethylene	Residue[1]	No Residue	Significance	Overall
Tufflite 3	78.5a[2]	80.5a	**	79.6a
C-I-L 3	76.5b	79.3ab	*	78.0b
Monsanto 703	75.0b	78.8b	***	77.1b
Monsanto 603	72.8c	74.4c	*	73.7c
VisQueen 1704	70.1d	74.0c	***	72.2d
PolyDress	69.3d	71.7d	***	70.6e
Monsanto Cloud Nine	64.4e	70.7d	***	67.9f
Range	13.9	9.8	—	11.7

[1]Transmission measurements were taken from 4-9-85 to 4-21-85 through polyethylene films that had accumulated a residue of ambient particulate matter. Thereafter, the films were washed every other day, and transmission recorded daily from 4-22-85 to 5-4-85.
[2]Mean separation within columns using Duncans multiple range test at the 0.05 level of significance.
[3]Separate F-tests were conducted for each polyethylene film, with *, **, and ***, indicating significance at the 0.05, 0.01, and 0.005 levels, respectively.

of daily cumulative PPF as much as the other polyethylene films. This seemed to account for the C-I-L 2 ranking second in transmission among the weathered films, as compared to its lowest ranking when the films were initially set outdoors.

When spectral transmission was monitored, it became apparent that differences in transmission of PAR (400 nm to 700 nm) resulted from differences in transmission between 400-500 nm. From a plant growth perspective, differences among films in the 400-500 nm wavelength may have an impact upon plant photomorphogenic responses (8). There were also considerable differences in transmission among films in the 300-400 nm region. However, from a practical standpoint, it is undetermined what effects these differences may have on plant growth.

The rankings of integrated spectrophotometer generated values within the 400-700nm range (PAR) differ from those generated in outdoor trials (Tables 1 and 4). This could be attributed to the differences in the physical environment when these polyethylene films were monitored. Differences in environment may include the angle of sunlight on the samples outside, temperature, reflection, dust and humidity. This suggests that laboratory methods for measuring transmission of PAR may not suitably predict the percentages of ambient radiation crops may receive under actual commercial use situations.

Table 4. Mean Percent Transmission of Total Radiation (TR), Photosynthetically Active Radiation (PAR), Infrared (IR) and Ultraviolet (UV) Radiation Transmitted Through Various Greenhouse Polyethylene Films[1,2].

Polyethylene	TR[2]	PAR	IR	UV
Monsanto Cloud Nine	81.0a[3]	80.8a	83.0ab	77.8a
Tufflite 3	80.9a	79.9a	84.0a	74.5a
Monsanto 703	80.6a	79.6a	83.0ab	76.6a
Monsanto 602	78.6b	78.7ab	81.8bcde	68.7b
C-I-L 3	76.7c	78.5ab	82.1bcd	54.8d
Monsanto 603	74.0d	77.0bc	82.6bc	39.2e
VisQueen 1504	75.8c	76.5c	81.4cde	59.1c
VisQueen 1704	76.0c	76.3c	81.4cde	59.1c
C-I-L 2	71.0e	73.5d	79.9f	36.3ef
PolyDress	70.1e	71.1e	80.9def	34.2f
Range	10.9	9.7	4.1	43.6

[1]Total radiation is defined as radiation from 300-850 nm, PAR as 400-700 nm, infrared as 700-850 nm, and ultraviolet as 300-400 nm.
[2]Methods used for quantifying transmission followed testing standards recommended by The American Society for Testing and Materials (3,4), and includes the use of a spectrophotometer equipped with an integrating sphere.
[3]Mean separation within columns using Duncans multiple range test at the 0.05 level of significance.

More research is needed to characterize why polyethylene films may perform differently in the field than would be suggested in lab studies. It is important to note that other characteristics of the polyethylene film greenhouse coverings examined, such as durability, strength, and tear resistance were not evaluated. Therefore, the use of these findings should be kept in perspective with other important polyethylene film features.

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Evaluation of Junipers for Mite, Disease and Insect Incidence: Secrest Arboretum—1990

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Abstract

Severe stunting and dieback of the new growth on certain juniper selections was noted in the summer of 1990. Ratings of tipdwarf mite damage, presence of spruce spider mites, and incidence of fungal tip blight disease were made for 64 juniper selections. Thirty-eight of the 64 selections exhibited damage from the tipdwarf mite, with seven selections exhibiting unacceptable damage, defined as stunting on more than 50 percent of plant stems. Thirteen of the 64 selections consistently had infestations of spruce spider mites, while 17 of the selections had no spruce spider mites. Positive visual fungal tip blight ratings were made on 33 of 64 selections in the field, but subsequent laboratory examinations confirmed the presence of fungal pathogens (*Phomopsis sp.*) on only four of these selections.

Introduction

This juniper evaluation will be conducted over the next five years and an interdisciplinary team including entomology, plant pathology, and horticulture specialists will make regular evaluations. Nurserymen are encouraged to visit the evaluation plots in the Secrest Arboretum at the Ohio Agricultural Research and Development Center in Wooster, Ohio.

Sixty-four selections in the genus *Juniperus* planted in the Secrest Arboretum in the Spring of 1986 and 1987 were evaluated for mite, disease and insect incidence in September of 1990. Plants were randomized in fully exposed sites in the Arboretum. Plants were provided by various Ohio nurserymen who were interested in studies of tip dieback problems on juniper.

Wheeler, et al. (1981) listed and described a large number of insect and mite pests of Pennsylvania junipers. The Pennsylvania survey was based on inspections of plant material in nurseries and landscapes but little reference was made concerning the incidence of these pests on particular juniper selections.

Juniper tipdwarf mite (*Trisetacus sp.*) causes stunting of new growth and feeding injury at the base of juniper foliage (5). Infested tips often have twisted, deformed, wavy foliage. Spruce spider mite (*Oligonychus ununguis* Jacobi) is a common cool season mite causing yellowing and bronzing of foliage on junipers and other conifers.

Fungal dieback and tip blights of juniper are caused by *Phomopsis juniperovora* Hahn, *Kabatina juniperi* Schneider and Arx, and *Sclerophoma pythiophila* (Cda.) Hohn. It is common that diagnosis of these diseases is made solely on the basis of field observations of brownish to ashen-gray areas of discoloration on spring growth (*Phomopsis sp.*, and late summer/early fall growth (*Kabatina sp.*), coupled with the observed presence of fungal fruiting bodies associated with the affected areas. This study examined whether plant tissue typically field-evaluated as tip blight of juniper was truly infected by *Phomopsis sp.* or whether other pathogens or causes were involved.

Materials and Methods

On September 10 and 25, 1990, 64 juniper selections were evaluated at Secrest Arboretum. Tipdwarf mite damage was rated on a 0-5 scale as follows:

0—No tipdwarf mite damage detectable (less than 10 percent of stems with stunting)
1—10-30 percent of stems with stunting.
2—30-50 percent of stems with stunting.
3—50-80 percent of stems with stunting. Unacceptable horticulturally.
4—80-90 percent of stems with stunting. Unacceptable horticulturally.
5—90-100 percent of stems with stunting. Unacceptable horticulturally.

Spruce spider mite counts were made by rapping a randomly-selected juniper branch four times on an 8.5" by 11" piece of white paper and counting the mites. Populations of more than 40 mites were counted as 40. Presence of plant bugs, oribatid mites, aphids and other insects was also noted.

For fungal tip blights, junipers were given initial field ratings; then samples from branches suspected of having tip blight were taken for laboratory microscopic examination.

Each juniper selection was represented by four randomized single-plant replications. Results are reported as averages of the four replications with the number of infested plants reported in parentheses (Table 1). For eight of the selections only three replications were rated, due to missing plants.

Results and Discussion

Tipdwarf mite damage was present on 33 of the 64 selections rated in the study, with seven selections exhibiting damage on more than 50 percent of the stems. Damage was greatest on selections of *Juniperus scopulorum*, *J. virginiana* and *J. chinensis*, with little or no injury on *J. sabina* and *J. horizontalis*. Damage from tipdwarf mite made some selections at this location unacceptably stunted and distorted in terms of landscape value.

Three of the 64 selections averaged 20 or more spruce spider mites per sample, which is considered by the industry to be the number that triggers an acaricide spray recommendation. Thirteen of the 64 selections had three or four of the replicates with spruce spider mite infestations. On 17 of the selections no spruce spider mites were detected.

Considerable tip dieback was noted on many of the juniper selections. Field ratings (based on symptoms) of fungal tip dieback were made on 33 of the selections, but subsequent laboratory examination confirmed a pathogen (*Phomopsis sp.*) on only four selections (*Juniperus chinensis* 'Gold Coast', *J. horizontalis* 'Blue Chip', *J. sabina tamariscifolia*, *J. sabina* 'Tam's New Blue'). Other fungal pathogens, such as *Kabatina sp.* and *Sclerophoma sp.* were not identified on the samples. The weak pathogens or saprophytic fungi *Discosia sp.*, *Pestalotia sp.* and *Sphaeropsis sp.* were found on several samples.

It appears from these results that field observations are not adequate for proper diagnosis of fungal twig diebacks of junipers; laboratory examination is essential. To identify fungus-caused tip damage and to rate selections, the planting should be examined at least twice per year: once, before new growth starts in spring, and later in the early summer or fall. This will be done in future years for this Secrest Arboretum study. Damage from winter injury, moisture stress, tip midge damage, other insect problems and even tipdwarf mite injury may be misdiagnosed as fungal diseases.

Juniper tip midges (*Oligotrophus betheli* Felt) were not confirmed on junipers in this study. However, damage on some plants was suggestive of juniper tip midge and juniper midge (*Contarina juniperina* Felt) injury, and these pests will be evaluated at Secrest Arboretum in spring of 1991. Some tips that had injury suggestive of midge injury contained an unidentified egg, probably of a leafhopper or plant bug.

Plants with a considerable dead foliage often contained large numbers of oribatid mites. It is suspected that these mites are feeding on fungi and decaying organic matter. These mites may be confused with spruce spider mites in casual field testing.

Unidentified aphids and plant bugs were also collected.

Table 1. Tipdwarf Mite Ratings and Spruce Spider Mite Counts.

	Tipdwarf Mites	Spruce Spider Mites
Juniperus chinensis 'Ames'	4.00(3)[1]	0[1]
Juniperus chinensis 'Aquarius'	0.75(3)[2]	10.25(4)[3]
Juniperus chinensis 'Armstrong'	2.50(4)	23.00(4)
Juniperus chinensis 'Blaauw'	1.50(4)	0
Juniperus chinensis 'Blue Point'	2.33(3)[1]	1.00(1)[1]
Juniperus chinensis 'Fruitlandii'	0.50(1)	4.75(1)
Juniperus chinensis 'Gold Coast'	3.75(4)	1.25(2)
Juniperus chinensis 'Gold Star'	0.25(1)	17.00(2)
Juniperus chinensis 'Hetz's Columnaris'	3.00(4)	4.50(2)
Juniperus chinensis 'Hooks'	3.50(4)	0.75(1)
Juniperus chinensis 'Keteleerii'	1.25(4)	2.75(2)
Juniperus chinensis 'Kohankie's Compact'	1.75(4)	0.50(1)
Juniperus chinensis 'Mission'	2.25(4)	2.00(3)
Juniperus chinensis 'Moraine'	0.50(2)	13.00(3)
Juniperus chinensis 'Owen's Compact'	3.00(3)	4.50(2)
Juniperus chinensis 'Ozark's Compact'	0.25(1)	14.50(2)
Juniperus chinensis 'Pfitzeriana Aurea'	1.50(3)	17.00(4)
Juniperus chinensis 'Pfitzeriana Nana'	4.00(4)	20.25(4)
Juniperus chinensis 'San Jose'	0	0.50(1)
Juniperus chinensis sargentii	0	1.75(1)
Juniperus chinensis sargentii 'Glauca'	0.25(1)	7.25(1)
Juniperus chinensis sargentii 'Viridus'	0[1]	4.66(3)[1]
Juniperus chinensis 'Saybrook Gold'	0	1.25(2)
Juniperus chinensis 'Sea Green'	1.00(3)	6.50(3)
Juniperus chinensis 'Spartan'	2.66(3)[1]	0[1]
Juniperus chinensis 'Spearmint'	3.25(4)	0
Juniperus chinensis 'Torulosa'	1.50(2)	0
Juniperus communis 'Depressa'	0[1]	0[1]
Juniperus communis 'Effusa'	0	0
Juniperus conferta 'Blue Pacific'	0	0.75(1)

(Continued)

Table 1. (Continued)

	Tipdwarf Mites	Spruce Spider Mites
Juniperus davurica 'Expansa'	0	1.25(1)
Juniperus horizontalis 'Bar Harbor'	0	0
Juniperus horizontalis 'Blue Chip'	0	0.50(1)
Juniperus horizontalis 'Blue Mat'	0	0
Juniperus horizontalis 'Emerald Spreader'	0[1]	6.67(2)[1]
Juniperus horizontalis 'Hughes'	0	7.00(3)
Juniperus horizontalis 'Jade River'	0	0
Juniperus horizontalis 'Wilmes'	0	1.50(1)
Juniperus horizontalis 'Youngstown'	0	9.00(3)
Juniperus horizontalis 'Prince of Wales'	0	0
Juniperus horizontalis 'Webber'	0	0.50(1)
Juniperus horizontalis 'Wiltonii'	0	0
Juniperus procumbens 'Green Mound'	0	0
Juniperus sabina 'Blue Forest'	0	20.00(2)
Juniperus sabina 'Broadmoor'	0	8.75(3)
Juniperus sabina 'Buffalo'	0	1.25(1)
Juniperus sabina 'Calgary Carpet'	0	0.50(1)
Juniperus sabina 'Skandia'	0	3.25(2)
Juniperus sabina tamariscifolia	0.50(1)	0
Juniperus sabina 'Tam's New Blue'	0.25(1)	2.50(2)
Juniperus scopulorum 'Admiral'	3.00(2)[1]	12.00(2)[1]
Juniperus scopulorum 'Gray Gleam'	2.75(3)	0
Juniperus scopulorum 'Pathfinder'	2.25(4)	0.50(1)
Juniperus scopulorum 'Skyrocket'	3.50(4)	2.25(2)
Juniperus scopulorum 'Tabletop'	0.50(2)	1.00(1)
Juniperus scopulorum 'Wichita Blue'	2.60(3)[1]	4.60(2)[1]
Juniperus squamata 'Blue Star'	0	0
Juniperus virginiana 'Burkii'	2.50(4)	1.75(2)
Juniperus virginiana 'Canaertii'	2.00(4)	1.25(2)
Juniperus virginiana 'Emerald Sentinel'	2.50(4)	0
Juniperus virginiana 'Grey Owl'	0.50(2)	8.50(4)
Juniperus virginiana 'Hillspire'	3.50(4)	4.25(2)
Juniperus virginiana 'Manhattan Blue'	0.75(2)	0.75(1)
Juniperus virginiana 'Silver Spreader'	2.00(4)	1.50(3)

[1]Three single-plant replicates were evaluated rather than four, due to missing plants.
[2]Average tipdwarf mite damage rating for four single-plant replicates, followed by number of plants affected. All tipdwarf mite ratings are averages for four replicates, except for those specifically noted as for three replicates.
[3]Average spruce spider mite counts for four single-plant replicates, followed by number of plants affected. All spider mite counts are averages for four replicates, except for those specifically noted as for three replicates.

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